THE BUILDING DECONSTRUCTION PROCESS AND THE DEBRIS TRAIL : TOWARDS A DYNAMIC MODEL

VOLUME 1 OF 2

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Abbreviations

ADEME	Agence de l'Environment et de la Maîtrisse de l'Energie
AECOPS	Associação de Empresas de Construção Civil e Obras Públicas do Sul (Building and Civil Engineering Contractors Association)
Agenda 21	The Action Plan from the Earth Summit from 1992
BBRI	Belgium Building Research Institute
BC	British Council
BEPAC	Building Environmental Performance Assessment Criteria
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environment Assessment
CAP.	*Per capita*
CARACAS	EU contaminated soils project research
CATWOE	Soft System Thinking mnemonic (Customers, Actors, Transformation process, *Weltanschauung*, Owners and Environment constraints).
CERF	Civil Engineering Research Foundation (American Society of Civil Engineers)
CESL	Consultores de Engenharia e Salubridade Lda.
C&D	Construction and Demolition Wastes
CHMR	Center for Hazardous Materials Research
CIB	Conseil Internationale du Bâtiment pour la Recherche l'etude et Documentation/International Council for Building Research Studies and Documentation
CIRIA	Construction Industry Research and Information Association
CIWMB	California Integrated Waste Management Board
CLARINET	Contaminated Land Rehabilitation Network for Environmental Technologies
CMS	Câmara Municipal de Silves (Portugal)
CML	Câmara Municipal de Lisboa (Portugal)
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation

CSTB	Centre Scientifique du Bâtiment (Building Construction Scientific Centre)
Dec. Lei	Law Decree
DG	Director General
DGA	Direcção Geral do Ambiente (General Directorate of the Environment)
DG XI	EC Directorate General XI
DOE	Department of Energy (USA)
EC	European Commission
EEA	Environmental European Agency
EDA	European Demolition Association
EGF	Empresa Geral de Fomento (Portuguese General Foment Enterprise)
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EMAS	Environmental Management and Auditing Scheme (EMAS)
EMU	European Monetary Union
EOP	Empreiteiro de Obras Públicas (Public Works Contractor)
EPA	Environmental Protection Agency
EPAC	Environmental Protection Agency Copenhagen
EPM	Environmental Preference Method
EQUER	Evaluation of Environmental Quality of Buildings
ERL	Environmental Resources Limited
ERRA	European Recycling and Recovery Association
ETCWEU	European Topic Centre for Waste European Union
EU	European Union
EUROSTAT	Environment Statistics
EVE	Environmental Value Engineering
EXPO'98	1998 Lisbon World Exposition
FEDER	Fundo Europeu de Desenvolvimento Regional (European Fund of Regional Development)
GFA	Gross Floor Area
Gj	Giga joule
GNP	Gross National Product

ICAT	Instituto de Ciências Aplicadas e Tecnologias (Applied Sciences and Technology Institute)
ICE	Institute of Civil Engineers
ICN	Instituto da Conservação da Narureza (Nature Institute Conservation)
IDE	Institute of Demolition Engineers
IDICT	Instituto de Desenvolvimento e Inspecção das Condições de Trabalho (Working Conditions and Development Inspectorate Institute)
INAG	Instituto Nacional da Água (National Water Institute)
INAMB	Instituto Nacional do Ambiente (National Environmental Institute)
INE	Instituto Nacional de Estatística (National Statistic Institute)
INETI	Instituto de Engenharia e Tecnologia Industrial (Industrial Engineering and Technology Institute)
INMG	Instituto Nacional de Metereologia e Geofísica (Natural Meteorological and Geophysical Institute)
INR	Instituto dos Resíduos (Waste Institute)
IPAMB	Instituto de Promoção Ambiental (Environment promotion Institute)
IPE	Institute of State Participations
IPPC	Integration Pollution Prevention Control Directive
IPTS	Institute for Prospective Technological Studies
ISO	International Standard Organisation
IST	Instituto Superior Técnico
ISWA	International Solid Waste Association
ITEC	Institut de Tecnologia de la Construcció de Catalunya (Spain)
IUCN	International Union for the Conservation of Natural Resources
Ka	Kilometer
KWh	Kilowatt hour
LCA	Life Cycle Assessment
LNEC	Laboratório Nacional de Engenharia Civil (National Civil Engineering Laboratory)

LULU	Locally Undesired Land Use
MA	Ministério do Ambiente (Ministry of the Environment) (Portugal)
MARN	Ministério do Ambiente e Recursos Naturais (Ministry of the Environmental and Natural Resources)
MEE	Ministry of Environment and Energy (Denmark)
MEPAT	Ministério do Equipamento Planeamento e Administração do Território (Ministry of the Equipment, Planning and Country Planning)
MHOP	Ministério da Habitação e Obras Públicas (Ministry of Housing and Public Works)
MHSPE	Ministry of Housing Spatial Planning and Environment (The Netherlands)
MSW	Municipal Solid Waste
NEF	New Economist Foundation
NGO's	Non Governmental Associations
NICOLE	Industry Contaminated Land Project Research
NL	Netherlands
NIMBY	Not In My Backyard
OECD	Organisation for Economic and Co-operation Development
O J.	Official Journal (European Union)
PER	Planos Especiais de Realojamento (Special Re-accommodation Plans)
PERSU	Plano Estratégico de Resíduos Sólidos Urbanos (Municipal Solid Waste Strategic Plan)
POA	Programa Operacional do Ambiente (Operational Programme of the Environment)
PNPA	Projecto Nacional de Política do Ambiente (National Environmental Policy Project)
PNUD	Plano da Nações Unidas para o Desenvolvimento (United Nations Development Plan)
PPNR	Projecto de Plano Nacional de Resíduos (National Waste Project Plan)
PRISM	Preserving Resources through Integrated Sustainable Management of Waste

PSR	Pressure – State – Response
PTI	Public Technology Inc. (USA)
RICS	Royal Institute Chartered Surveyors
RILEM	International Union of Testing and Research Laboratories for Materials and Structures
RIO+5	United Nations Conference at New York five years after the Earth Summit held at Rio de Janeiro (Brazil) in 1992
SETAC	Society of Environmental Toxicology and Chemistry
SPV	Green Point Society
SSM	Soft Systems Methodology
SWANA	Solid Waste North America Association
TC	Technical Committee
TG	Task Group
TPM	Total Project Management
UK	United Kingdom
UGT	União Geral de Trabalhadores (General Workers Union)
UN	United Nations
UNCSD	United Nations Commission for Sustainable Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNIDO	United Nations Industrial Development Organisation
UNITAR	Unite Nation Institute for Training and Research
UNL	Universidade Nova de Lisboa (New University of Lisbon)
UNEP	United Nations Environment Programme
UNITAR	United Nation Institute for Training and Research
UNGASS	United Nations General Assembly Special Session
UNU	United Nations University
USA	United States of America
USEPA	United States of America Environmental Agency
US	United States
USGBC	United States Green Building Council
UTL	Universidade Técnica de Lisboa (Technical University of Lisbon)
WCED	World Commission on Environment and Development
WHO	World Health Organisation

WRF	Waste Resource Foundation
WTO	Word Trade Organisation
WWF	World Wide Fund for Nature
Yr.	Year

Abstract

Waste production and management problems have increased in this century. Population growth and consumption patterns in developing societies are associated with this growth. During the last decades, some world organisations have contributed to a global discussion and common resolutions. Concerns about the environment and sustainable development have been soundly highlighted. The European Union through its five Environment and Development Programmes as well the Directives and other special Regulations have responded that Agenda 21.

The complexity and historical context of integrated and sustainable waste management is studied within the context of the construction industry in Portugal. International experience and knowledge were also drawn upon to add to the local knowledge. The study classifies the debris trail. The deconstruction process is studied in order to illuminate the relationship with the nature of the debris trail. This is the core of the research which seeks to make a contribution to the understanding of this relationship and forms the basis for the development of a dynamic construction and demolition estimating and assessment model.

The work is based on case studies derived by observation from five complex and holistic case studies in Lisbon, cases studies reported from other countries and from work by others undertaken in France. Soft Systems Methodologies are used to illuminate the qualitative concerns. The quantitative information from practice is placed along side the qualitative data to give further insight into the issues being studied. The

difficulties of insufficient actor involvement and participation in the process are also discussed.

Systems Dynamics methodologies are used to define a dynamic model using data from the sources referred. The model is intended to assist the assessment and estimation of the characteristics of the debris trail. The output of the dynamic model will contribute to a national strategy and plan for the construction and demolition waste stream in Portugal within the context of European Union strategies and guidelines.

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“ I have no special talents.
I am only passionately curious”

Einstein 1952

CHAPTER 1:

INTRODUCTION

"Development and conservation are equally necessary for our survival and for the discharge of our responsibilities as trustees of natural resources for the generations to come."

(IUCN 1980:1)

This thesis is about the building deconstruction process and the debris trail, towards a dynamic model. The model has the aim to contribute to the better understanding of the construction and demolition waste stream. The study of the quantitative and qualitative characteristics of the wastes from deconstruction are studied in an inter relationship with the sustainability concept. The environmental concerns are always present in the work developed.

In 1962, Rachel Carson's book entitled "Silent Spring" was published (Carson 1962). For the first time, this book highlighted the real world effects of pollution. Since then the world has become sensitised to the threats to the planet life support system and to the effects of excessive consumption in this new and increasingly economic society. In the early 1970's, a group of leading industrialists meet in Rome to discuss their concerns about environmental degradation. They became known as the Rome Club. Their concerns led to the publication of "Limits of Growth" in 1972 (Meadows, Meadows and Randers 1972).

This book looked at the environmental effects of a range of different scenarios. For example, the effects of a rapid increasing population or increasing raw materials extraction. The work received a great deal of criticism but the central thesis of the work, that there is a finite limit to the growth in resource consumption, remained intact. In the same year, the first major environmental conference was hosted by the United Nations in Stockholm (MHOP 1978). The outcome of this conference was the general recognition that environmental issues needed to be addressed on a global basis. However, the attention of the world was often diverted onto other issues such as the cold war, increasing North – South economic divide, and third world development problems (MHOP 1978). Therefore it was only in 1987 that the report "Our Common Future" was published (WCED 1987). This report is known primarily for its definition of sustainable development and its acknowledgement that sustainable development is essential for the future of our planet. Sustainable development was defined as "meeting the needs of the present without compromising the ability of future generation to meet there own needs." This thesis adopts this definition and it will be discussed in the next chapter.

The next major development was the United Nations Conference on Environment and Development held in Rio de Janeiro in June 1992, known as the "Earth Summit". The output from this conference was an agenda for action called "Agenda 21" (UN 1992a). The agenda constituted an agreed work programme for the international community for the period beyond 1992 and into 21st century. The work programme could be summed up with the phrase "Think globally act locally". Each country was to develop a range of projects to address their environmental problems. Agenda 21 popularised the Sustainable Development concept because this area was key to dealing with environmental issues in most countries. Another output of this conference was the "Earth Charter". This Charter is a declaration of basic human rights and obligations with respect to environment and development. It constitutes an important document in the environmental context.

SECTION 1: FROM DEVELOPMENT TO SUSTAINABLE DEVELOPMENT

Since the Rio Conference in 1992, the debate about environmental issues and sustainable development has widened. Increasingly the growing deterioration of our environment has been linked to the lack of adequate economic development in some countries. This concern has been expressed by organisation as diverse as the OECD and World Bank and as Friends of the Earth and Oxfam (Eloy 1992). In 1998, the United Nations highlighted this concern (PNUD 1998) saying that even in industrialised and developed countries like the United States, with the highest incomes in the world, 17% of the population is below the poverty line (PNUD 1998). This growing concern has lead to not only the action to promote economic growth, but also environmental sustainability and action against poverty.

Rich and poor countries, with different political and social systems, must eliminate the gap where poverty and underdevelopment mark the distance of development and justice. This idea was emphasised in last United Nations Conference Rio+5 in 1997. Experience tell us that conservation is a social challenge. A critical part of this challenge is the widening poverty gap (WWF 1997:2). It is impossible to speak about sustainable development in a world where a quarter of the population is poor[1], and where 20% of the population consumes 80% of the resources (IPAMB/MA 1997).

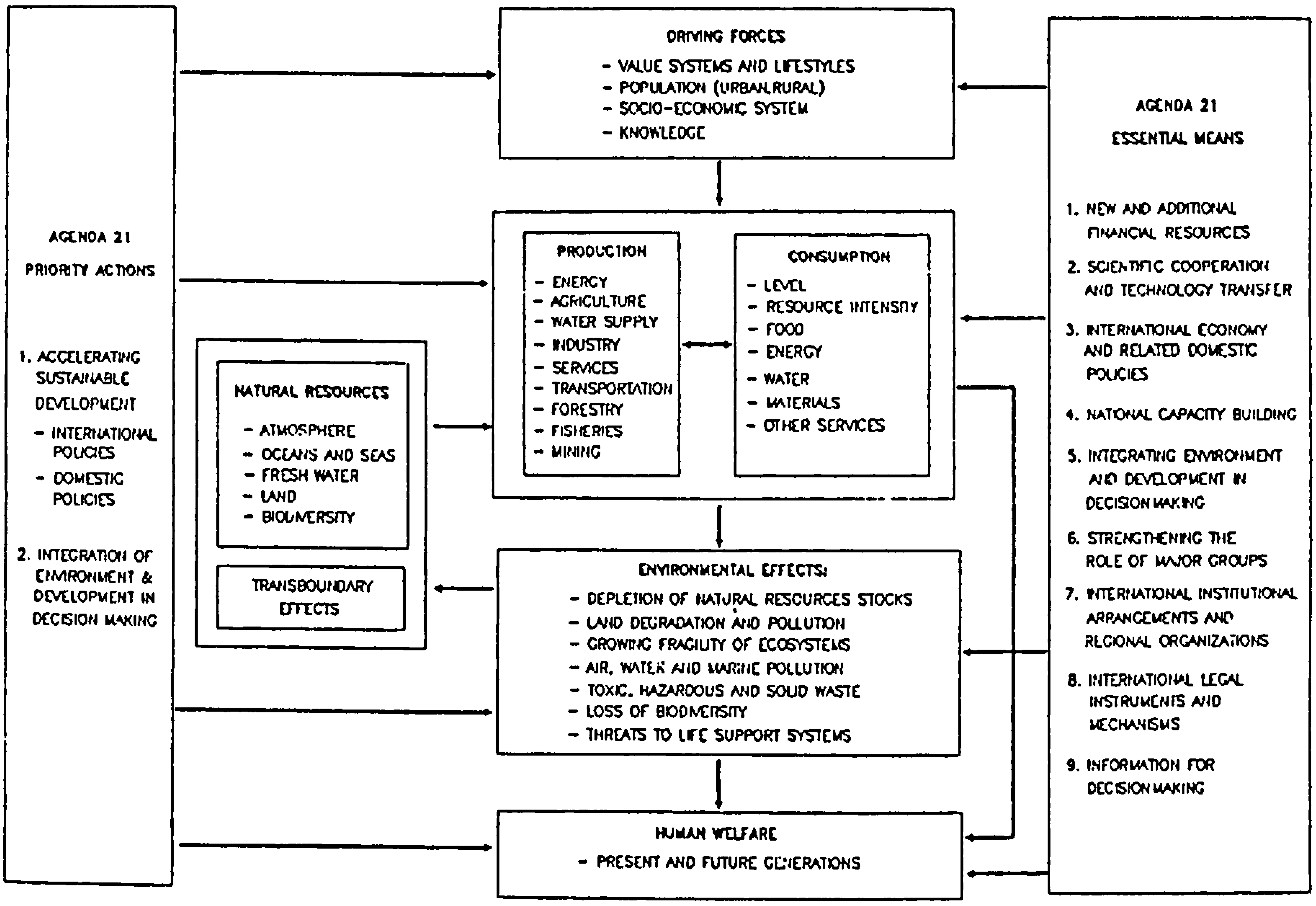
For example, the per capita consumption of energy in the European Union is half that of the USA and Canada. But it is still over 10 times greater than that of the majority of developing countries. A child born in the European Union will consume over 20 times as many natural resources during its lifetime, than a child born in the majority of developing countries. Although still half that of an American child (EC 1992b:17).

In July 1997 (UN 1997a) twenty-five years after the first major environmental conference in Stockholm, a United Nations Special Assembly Session (UNGASS) was called. It was decided that the first action to be implemented to achieve sustainable development was the promotion of appropriate actions to fight poverty (IPAMB/MA 1997). There is now a clear recognition that making economic growth and the reduction of poverty compatible with environmental sustainability is fundamental to success (Figure 1.1).

In summary, over the past thirty-five years, there is a growing recognition of the importance of environmental issues. In the last decade, environmental concerns have increasingly been linked to economic development. Environmental sustainability incorporates a diverse range of issues, and associated concepts. Sustainable development is a key concept, as is sustainable construction. Both of these concepts are considered in detail in later chapters. Waste management, which is at the core of this thesis is a key element within these concepts.

[1] Poor population is characterised by or indicating poverty. This is the condition of being without adequate food, money, etc. (Oxford Dictionary 1995).

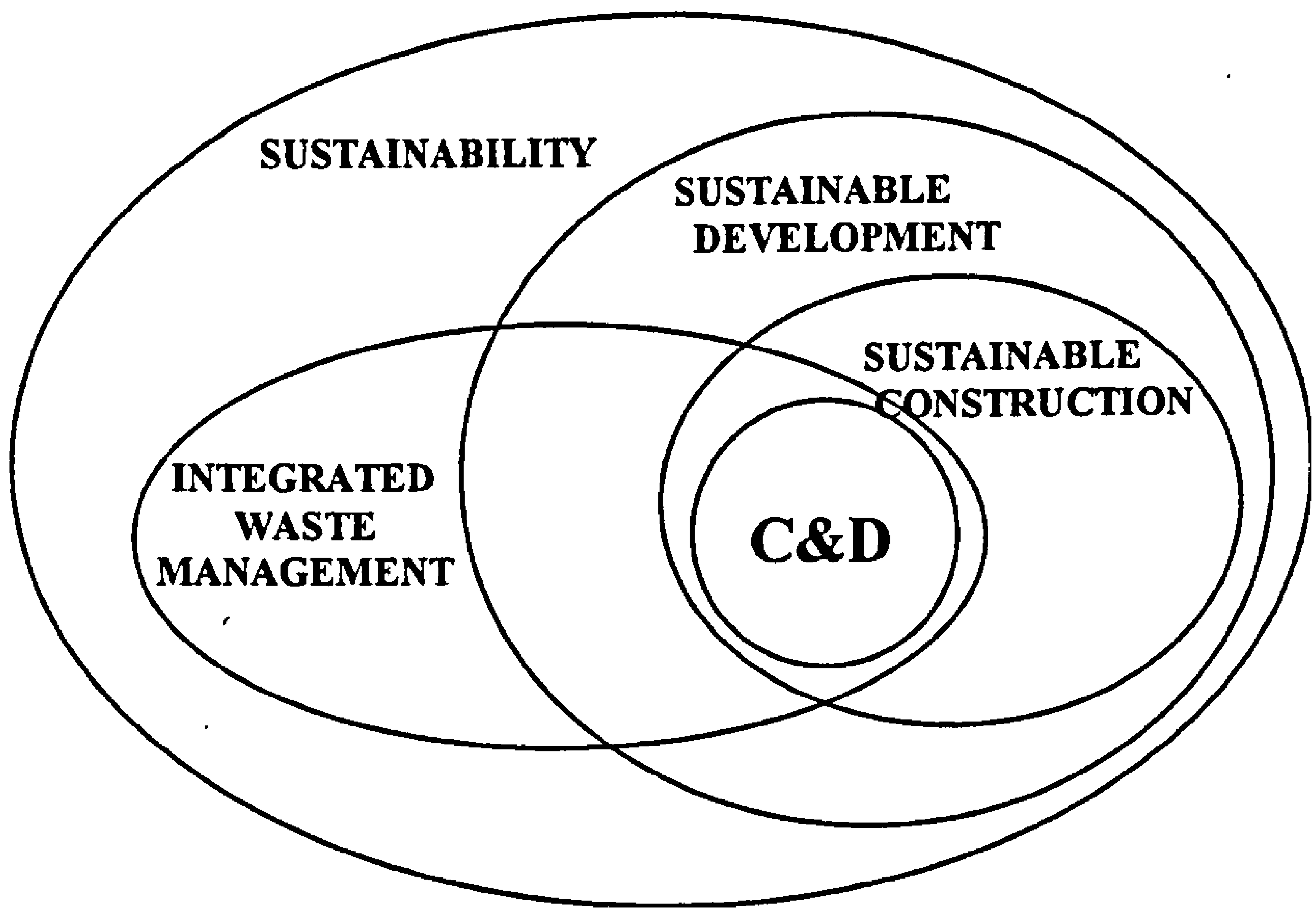
Figure 1.1 – Revitalising growth with sustainability



Source: UN 1992b:21.

Both these concepts are contained within the overall concept of sustainability. This is demonstrated in Figure 1.2. The relationship and inter activity between sustainability concepts towards the core of this research is expressed in the figure. Waste management issues overlap those of sustainable development but they do not cover the same area. The area of overlap between these concepts and the focus of this thesis is that of construction and demolition waste.

Figure 1.2 - Diagrammatic representation of the interrelationships between sustainability concepts and research focus



SECTION 2: REASONS FOR THIS RESEARCH

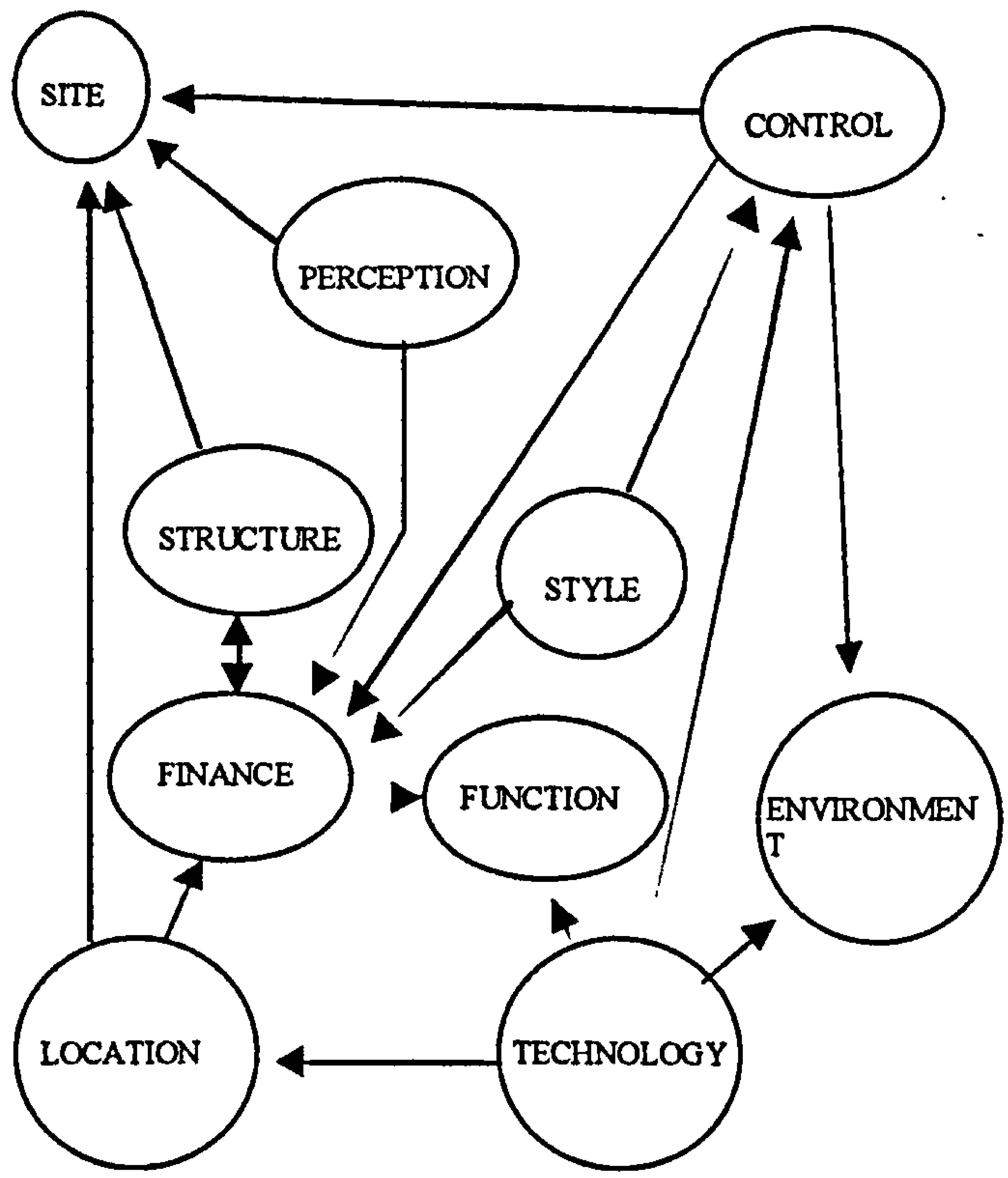
The principles of sustainability require a global approach to waste production minimisation, as well as the efficient use of materials and components, and the reuse and recycling of wastes from an energy minimisation point of view. This applies as much to the construction industry as to every other industry.

Construction activity and processes, from inception, production, maintenance and demolition have a significant impact on the environment (Golton 1995a). Building activity represents approximately half of the total energy consumed in high consuming countries such as UK (Golton 1995a:10). It is difficult to control the impact of buildings on the environment where there is an absolute need to preserve natural resources or minimise energy consumption. This despite the availability of energy minimisation strategies or low embodied energy materials and components.

This thesis focuses specifically on waste in the construction and demolition process. The waste stream is defined as the waste output of an area, location, or facility (Tchobanoglous, Theisen and Vigil 1993) and the debris trail is the drag or stream of fragments of something destroyed or broken down (Oxford Dictionary 1995). On construction industry context debris trail are the aggregates which result from construction or demolition process. The debris trail, becomes more and more well defined and characterised as we advance in the direction of sustainable construction.

Construction and demolition waste streams, result from the construction and renovation process including restoration, refurbishment and rehabilitation projects. It also occurs on re-paving projects, bridge repairs, and on clean ups associated with natural and environmental disasters. Another key source of construction waste is through the deconstruction of buildings. This last step happens when a building becomes obsolete. Buildings become obsolete for many reasons including physical deterioration, economic changes, functional changes, technological progress, social changes and legal requirements (Flanagan et al. 1989:39). Golton (1989) discussed the nature and degrees of obsolescence and posits a taxonomy of obsolescence and its patterns. Figure 1.3 represents this complex relationship.

Figure 1.3 – Patterns of Obsolescence



Source: Golton 1989, Fig. 1.

The deconstruction of a building has two phases. The first phase is the dismantling and salvaging phase. Here, striping out contaminated material is a priority. Removal of hazardous materials such as asbestos, lead in piping systems, timber painted with contaminated paints, as well as other contaminated materials, must proceed the demolition phase (Curwell and March 1995:113). The second phase is the selective demolition phase. When considering the waste streams, both these phases must be taken in consideration.

This research deals directly with the need to contribute towards sustainable construction through analysis of the debris trail associated with construction and demolition waste. This analysis should improve our understanding, of construction and demolition waste stream. With an improved understanding it should be possible to develop a model of the process involved. This model will assist in the development of an estimating and assessment tool. This tool should assist practitioners in implementing sustainable construction strategies by reducing the debris trail and increasing reuse and recycling of the components and materials.

SECTION 3: CONSTRUCTION AND DEMOLITION WASTE STREAM

Typically construction and demolition wastes contain (Tchobanoglous, Theisen and Vigil 1993:749):

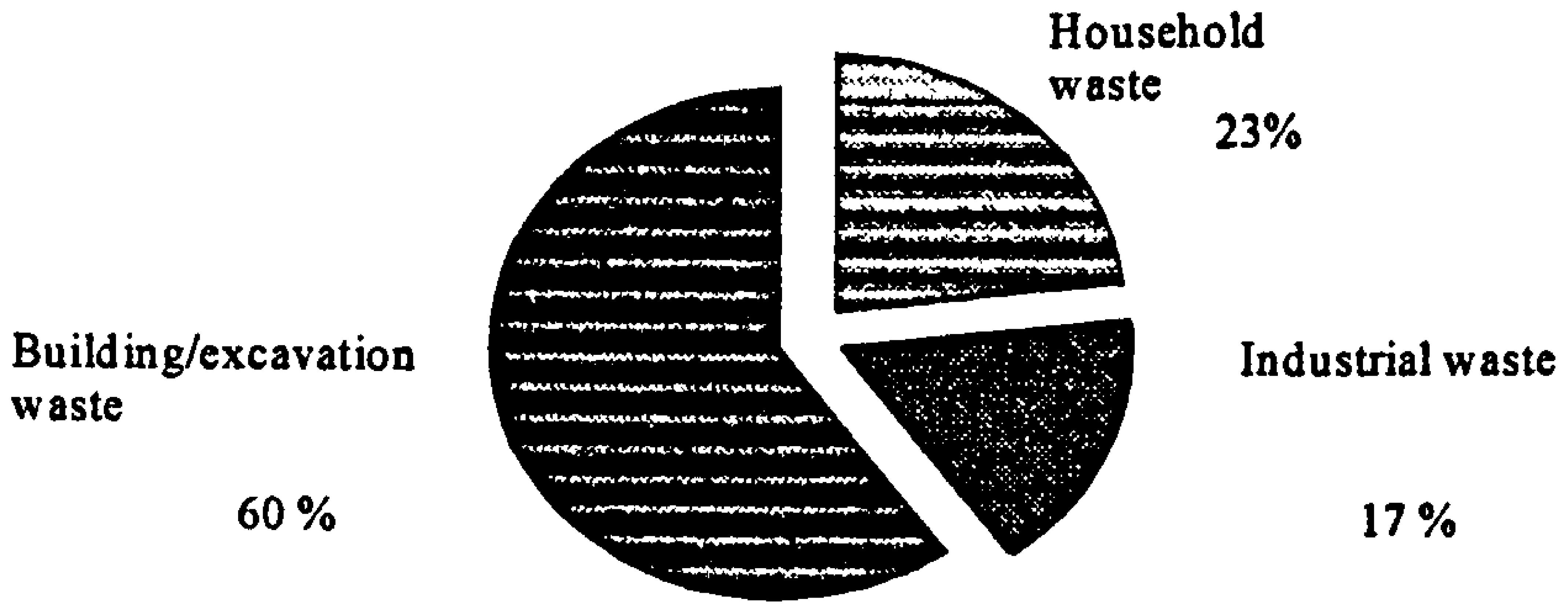
- 40 to 50 percent concrete, asphalt bricks, block, and dirt.

- 20 to 30 percent of wood and related products (pallets, stumps, branches, forming and framing timber, treated timber and shingles).

- 20 to 30 percent miscellaneous wastes (painted or contaminated timber, metals, tar-based products, plaster, glass, white goods, asbestos, and other insulation materials, plumbing, heating and electric parts).

Wastes resulting from construction and demolition operations represent a significant percentage, in the order of 60% in the UK (ICE 1995), of the total wastes arising to landfill. In many countries, such as Portugal, the amount of such wastes disposed to landfill is increasing but it is hard to say by how much (MA/INR 1997). Household waste recycling has attracted much attention in recent years. Yet construction waste, which represents a greater proportion of the total of all waste, and arguably gives rise to greater problems such as illegal dumping, has not attracted the same sort of consideration by professionals in the construction industry. Around half of the waste that goes to landfill can be from construction. A major construction project can completely overwhelm local landfill. Figure 1.4 gives information about landfilled waste composition in a typical county within the UK (ICE 1995).

Figure 1.4 – Landfilled waste composition in a typical county within the UK



Source: ICE 1995: 4

Comparable Classification Criteria

In order to truly compare between countries, it is necessary to define global compatible classification criteria in waste stream all over the European Union (Morgan and Argus 1995:Part 3:8).

The European Recycling & Recovery Association supported a study of the packaging waste stream (ERRA 1996). The first case studies were in Europe, included a study in the Oeiras municipality of Portugal. The study highlighted the need to adopt common criteria to compare data and results on all the case studies. This position was also well expressed in a recent study by Thurgood (1998:4). She states that "there is no international agreed definition of Municipal Solid Waste (MSW). At the two extremes MSW always includes waste from households but never agricultural wastes. It usually includes commercial wastes from shops and offices". In a few cases (for example in Denmark and Austria) it also includes industrial wastes. Construction and demolition wastes are typically included in the industrial waste subcategory.

To calculate recycling rates, most countries first divide their total MSW arising by the number of inhabitants to produce amounts of wastes in kilograms per person per year (Thurgood 1998). The amount of wastes that has been recycled is then expressed as a percentage of this. Clearly then, the more categories of wastes that are added to the MSW stream, the higher the total figure of waste per inhabitant. If the waste stream includes, say, scrap cars which are both heavy and extensively recycled, a very different picture of recycling emerges than that from a country which excludes those classifications and only includes household and commercial waste in its Figures. Table 1.1 shows this situation.

Table 1.1 – Types of waste included in Municipal Solid Waste Statistics

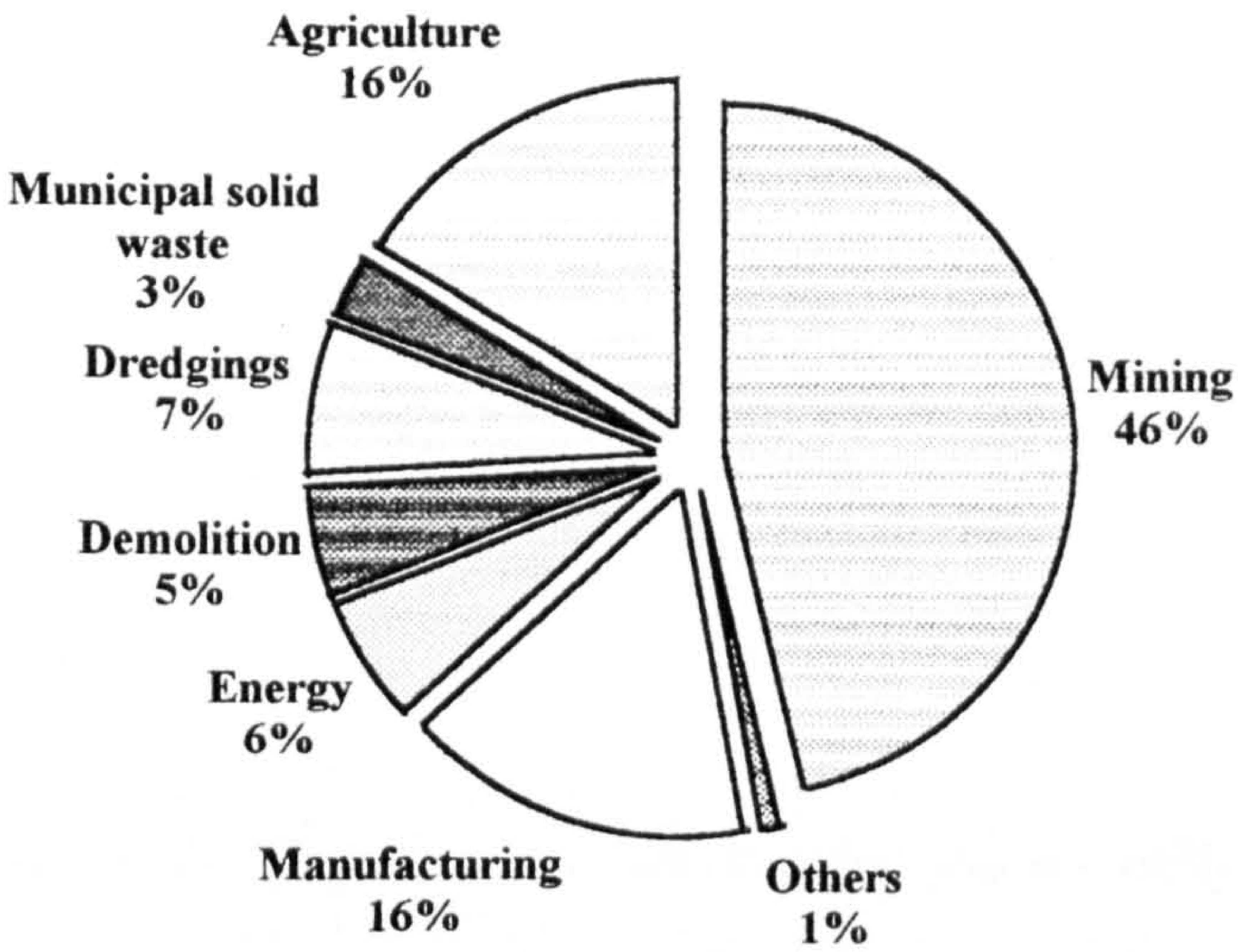
	Household	Commercial	Industrial (incl C&D)	Hazardous
Copenhagen,Denmark	X	X	X	X
Helsinki,Finland	X	X	X	X
Hampshire, UK	X	X		
Pamplona, Spain	X	X		
Malmo, Sweden	X	X	X	
Brescia, Italy	X	X		X
Prato, Italy	X	X		
Vienna, Austria	X	X	X	

Source: Thurgood 1998:4.

In a global perspective, the definition of what categories are included in MSW needs to be defined because it is a significant factor that must be included in the global strategy for waste. In particular, it will influence the priorities established for this waste stream. A significant example of this priority is the document "Making Waste Work, a strategy for sustainable waste management in England and Whales" (Department of the Environment and the Welsh Office 1995).

An estimated five billion tonnes of solid wastes are generated annually in Western Europe (Warmer Bulletin n° 47 1995: Information Sheet), the proportions of which are shown below in Figure 1.5.

Figure 1.5 – Solid waste generation in Western Europe

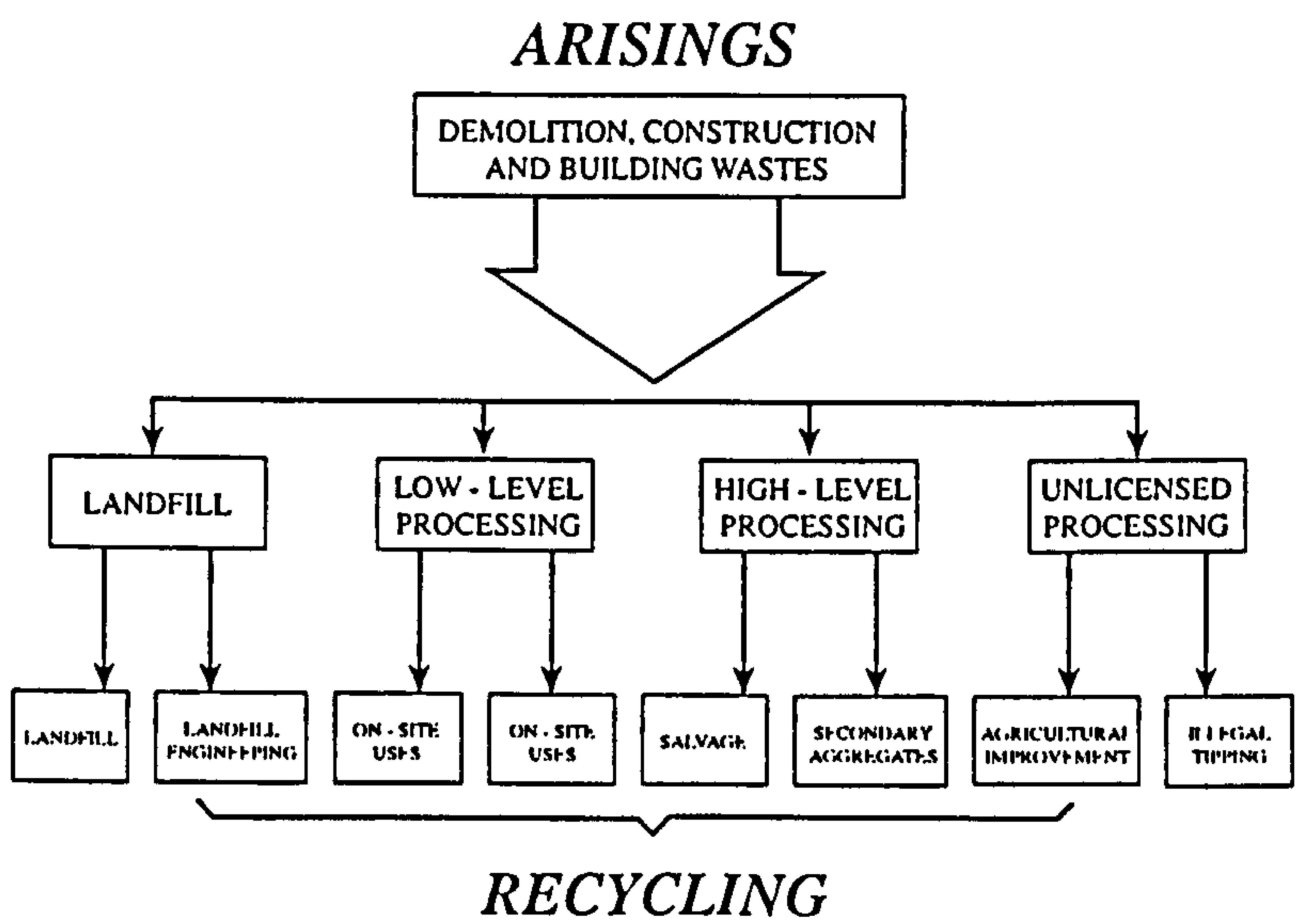


Source: Warmer Bulletin n° 47 1995:4.

The majority of municipal solid waste is bulky and inert, and is not susceptible to treatment such as incineration or biodegradation. An UK official document (DoE 1995b:ix), states that only 63% of demolition and construction wastes arising are currently recycled. It recommends that a target level of 75% be set for the year 2005. In the same document, the options for the management of demolition and construction wastes are presented as shown in Figure 1.6.

The recent survey by the EU reveals data from some other European countries (Morgan and Argus 1995). The data is constrained by several factors. These factors include, the nature of the civil works which have been studied, such as building demolition, renovation, rehabilitation, refurbishment, civil engineering works and road construction for example.

Figure 1.6 – Options for the management of demolition and construction wastes



Source: DoE 1995b:20.

The data is also influenced by the construction and demolition techniques and the materials used in the buildings studied. The regional climate and other characteristics will influence the difference in data between countries and regions in Europe. There is no information on the extent or influence of these issues. Another important consideration is the significant absence of data from the Southern European countries, with building typology and characteristics similar to the Portuguese ones (Morgan and Argus 1995). Buildings in Northern European countries are significantly different from those produced in Southern European countries. Table 1.2 presents the level MSW production and the level of construction and demolition waste stream production in some European countries (Procesl 1997:78).

Table 1.2 – Construction and demolition wastes and Municipal Solid Waste in Europe

COUNTRY	YEAR	ANNUAL QUANTITIES (1.000 TON)			OBSERVATIONS
		MSW (a)	(C&D) (b)	(b)/(a)	
GERMANY	1990	27 958	120 394	4,3	(2)
AUSTRIA	1990	4 783	18 309	3.8	(1)(2)
BELGIUM	1988	3 410	680	0.2	(1)
DENMARK	1985	2 430	1 747	0,7	-
SPAIN	1990	12 546	22 000	1,8	(2)
HOLLAND	1990	7 430	12 390	1,7	(1)(2)
IRELAND	1984	1 100	240	0,2	(2)
ITALY	1991	20 033	34 374	1,7	-
UNITED KINGDOM	1990	20 000	32 000	1,6	(1)(2)
CHECK REPUBLIC	1987	2 600	2 667	1,0	(1)(2)
SLOVIC REPUBLIC	1987	1 901	5 977	3,1	(2)
SWEDEN	1990	3 200	1 200	0,4	(2)
SWITZERLAND	1990	3 000	2 000	0,7	-

(1) EXCLUDING (DREDGING WASTES)
(2) EXCLUDING (MINING WASTES)
Source: Procesl 1997:78.

Recycling of Construction and Demolition Waste

Denmark is one of the countries where the recycling efforts in construction and demolition waste stream have achieved good results (Morgan and Argus 1995). The levels of production of wastes and recycling in Denmark are presented on Table 1.3 (MEE 1997).

Table 1.3 – Production and recycling of waste in Denmark in 1994, 1995 and 2000 Action Plan

DENMARK	RECYCLING					
	1994		1995		AP-2 000	
SOURCE	1 000 t	%	1 000 t	%	1 000 t	%
HOUSEHOLDS	558	22	628	24	1 050	49
INSTITUTIONS, TRADE & OFFICE	203	31	317	38	360	60
MANUFACTURING	1 140	49	1 446	56	1 200	57
BUILDING & CONSTRUCTION	2 052	84	2 173	85	1 100	58
SEWAGE TRET.PLANTS	688	72	686	71	750	50
COAL-FIRED POWER STAT.	1 319	67	1 564	92	900	56
OTHER	0	2	0	3		
TOTAL	5 960	55	6 814	61	5 360	54

Source: MEE 1997:30.

Recycling of construction and demolition waste increased from around 10% in 1985, to around 80% in 1993 (MEE 1996:5). Selective residential trials have shown it is possible to recycle up to around 90%. The Waste Management Plan of the city of Copenhagen (Teisen 1996) in particular highlighted this development. It showed that the waste streams have been redirected from mainly disposal to mainly recycling between 1988 and 1994. Simultaneously 47,000 tonnes of waste per year was redirected from disposal to incineration producing heat and power. These changes are presented in Table 1.4 (Jull 1996:6). Teisen (1996) attributes these changes to the recent initiatives that have taken place to increase recycling in

Denmark. Those initiatives were the introduction of different levels of waste tax on incineration without production of useable energy and landfill disposal. It has been established that recycling of construction wastes is now an integrated part of waste management.

Table 1.4 – Disposal of construction and demolition waste in Copenhagen 1988-1992

YEAR	Recycling		Incineration		Disposal		Total
	%	(tonnes)	%	(tonnes)	%	(tonnes)	(tonnes)
1988	16	62 500			84	319 500	382 000
1992	85	322 150	13	47 000	2	7 200	377 350

Source: Juùl 1996:9.

Efforts in construction and demolition recycling were intensified from 1986 with the adoption of a development programme for construction and demolition recycling (Teisen 1996). The Danish Environmental Protection Agency have set up a working group with the task of co-ordinating projects, within the framework of the development programme. More than 40 development projects were carried out during the period of 1987 to 1993, and the results of that work are presented in Table 1.5.

Table 1.5 – Solutions to demolition waste in Denmark. Evolution from 1988 to 1994

DEMOLITION WASTE (ton waste/year)							
YEAR	RECYCLING		INCINERATION		DEPOSIT		TOTAL
1988	62.500	16%	0		319.500	84%	382.000
1994	407.000	87%	47.000	10%	13.000	3%	467.000

Source: Teisen 1996:103.

However there is considerable further potential for the use of recycled construction and demolition waste in place of primary aggregates and other quarried building materials. Using construction and demolition waste in this way has a double benefit. It reduces both the amount of waste, which is landfilled, and reduces the environment impacts of quarrying primary minerals.

The reclamation of construction and demolition wastes leads to the following advantages (Warmer Bulletin N° 47 1995:14):

- Reduced quarrying and mineral extraction.

- Reduced landfill demand.

- Reduced transport costs when reused on site or nearby.

- Reduced environmental impacts.

- Improved profits.

The construction and demolition waste steam is a priority waste stream as defined by the European Union. To reach these goals, there are factors which need to be addressed, such as:

- consistency of supply.

- consistency of material.

- increased labour costs.

- additional on site processing.

- need for more complex management of projects.

- where materials are reprocessed on site there may be additional noise and atmospheric impacts.

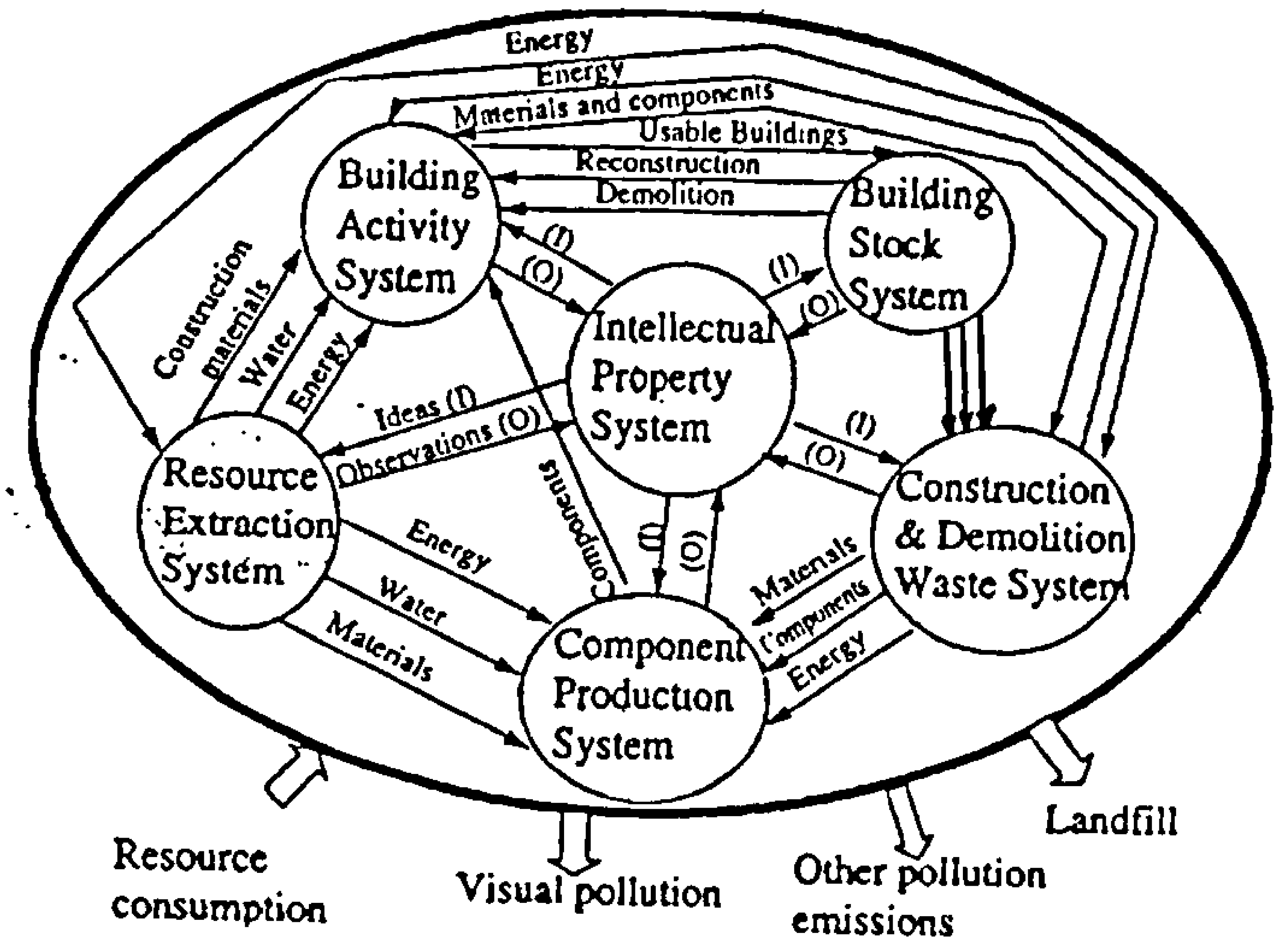
It can be seen that the construction and demolition waste stream is potentially a rich source for the reduction of waste and increase in reuse recovery and recycling of materials.

A Conceptual Model of Impact of Building on the Environment

There is an integrated and inter related model involving construction and demolition waste. This conceptual and dynamic model was presented by Inácio and Golton (1997:106) at the Bizarre Fruit Conference at the University of Salford (see Figure 1.7).

In this model there are two kinds of activities. "Real world" activities, necessarily involving people in the problem situation, and "Systems thinking" activities which may or may not involve those in a problem situation, depending upon the individual circumstances of the study. These systems are integrated with the purpose of applying System Dynamics to facilitate an understanding of the relationship between the behaviour of a system over time and its underlying structure, policies and decision rules (Inácio and Golton 1997).

Figure 1.7 - Building + Construction Environmental Impact Systems



Source: Inácio and Golton 1997:106.

Inside this conceptual and global model are six interactive sub-systems. They work together towards a common objective. These are:

- Resource Extraction System. This system is linked with the extraction of natural resources, such as quarries, stones, sand, water and energy consumption.

- Component Production System. This is the system where different manufacturing materials are transformed and their components delivered to building works.

- Building Activity System. This is the system where all industrial activity in building is presented.

- Building Stock System. This is the system where all the materials, components and products for building application are available to be utilised at building works.

- Construction and Demolition System. This is the system which is the core of this research, and which deals with qualities and quantities of wastes produced in construction and demolition works. The research is focused on the demolition side.

- Intellectual Property System. This is the qualitative system which drives the other five systems. From it flows observations to the outside (O) and it receives information and ideas (I) from the other sub-systems.

The input is dedicated to natural resources. The model also has three outputs which are visual pollution, pollution emission and landfill requirements.

As presented in Figure 1.7, each sub-system has its quantitative inputs and outputs to and from the others inside the global model, such as materials, components and energy. An exception is the Intellectual Property System which drives all the sub-systems and where the inputs (information and ideas) and outputs (observations) are qualitative.

The construction and demolition waste system is the sub- system where the core of this research is located. This is the system that will be unpacked by this research. The aim being to maximise the reuse and recycling of materials, and minimise energy consumption. When unpacking the sub-system the research will illuminate the deconstruction process of the building and construction industry. It will illuminate the nature and the qualitative and quantitative aspects of the contents of the waste stream associated with this process. An additional output of the research is an estimating and assessment tool for the construction and demolition waste stream.

In summary there are five principal research questions addressed in this thesis:

1– How can we deconstruct a building that is no longer required within the concepts of sustainability?

2– What are the characteristics of the construction and demolition waste stream/debris trail?

3– How can the study of the debris trail contribute towards sustainable construction objectives?

4– To what extent can the construction and demolition sub system be developed to improve our understanding of the waste stream?

5– To what extent can a dynamic tool for estimating and assessment be developed that could better illustrate the relationship between the characteristics of materials in the waste stream and the nature of the deconstruction process?

6– How to maximise the likelihood of an appropriate human environment with an emphasis on technical, scientific, economic, social and cultural aspects, where all participants are involved in implementing an integrated strategy for sustainable construction?

SECTION 4: PORTUGAL AND THE WIDER CONTEXT

The context of this research is the situation in Portugal. In order to better appreciate the focus of the research, this section details Portugal's economic position in with EU. There is also a discussion of Portugal's construction and demolition waste stream in comparison with other European countries.

According to Eurostat (1997) and the National Statistics Institute (INE), one fifth of the Portuguese population is poor when compared with European indicators of development (INE 1998). In illiteracy, health and other significant economic, social and cultural levels, Portugal is at the bottom of the European Union. The country, with EU support, is directing strong efforts towards its economic recovery. This recovery is vital. The latest United Nations Development Programme (PNUD 1998) highlighted a bleak perspective for the future of the world where consumption increases in the rich countries increasing the gap between the rich and poor countries. Table 1.6 shows a comparison of the global Portuguese situation over the last ten years (Cardoso 1998:26).

Table 1.6 – Portugal 1997 and 1998, state of the indicators in UNDP report of Human Development.

Indicators	1997	1998	Best Country	Worst Country
Human Development Indicators from Report	31	33		
Human Development Indicator (124 countries)	0.890	0.892	0.960 Canada	0.185 S. Leone
Real dollars GDP	12.33	12.67	4.00 Luxemburg.	355 Congo
Life birth expectation	74.60	74.80	79.1 Canada	34.7 S. Leone
Life expectation rate	83	83	90 Canada	16 S. Leone
Maternal mortality rate (for each 100.000 birth)	15	·15	6 Canada	130 Romania
Public health expenses (total percentage)	9.80	9.80	30.70 Japan	Insufficient data
Public health expenses (GDP percentage)	6.20	6.20	3.30 USA	Russia
Work force (total population %)	49	50	56 Denmark	37 Tajirgistan
Unemployment (x 1000)	258	344	5 Luxembourg	4.78 Hungary
Total unemployment Rate	7.10	7.50	2.50 Luxembourg	7.6 Spain
Injuries and deaths in road Accidents (per 100.000 inhabitants)	517	671	1283 USA	9 Albania

Defence expenditure (1995 per capita dollars)	283	289	1624 Israel	10 Kirgistan
Annual population growth Rate 70-95 years	0.3	(-) 0.1	1.8 Uzbekistan	(-) .7 Latvia
Total fertility rate	1.5	1.5	4.1 Tadjikistan	1.2 Italy
R &D (per 1.000 inhabit.)	1	1	7 Japan/Sweden	Malta

Source: Cardoso 1998.

Construction and Demolition Waste Stream

In Portugal, the National Environment Policy Plan (MARN 1995a:56) does not refer to the construction and demolition waste stream. According to the Solid Wastes National Strategic Plan (PERSU) (MA/INR 1997:91), the absence of data to characterise this waste stream is a weakness. The need for further data and research is emphasised in the report. The National Waste Project Plan (PPNR) (MARN 1995b:41) made the same plea for further research. However it made no reference to the construction and demolition waste stream.

Both the State of the Environment Report 1994 (MA/DGA 1995b:159) and the preliminary version of the State of Environment 1995 (MA/DGA 1996: Chapter 4) were silent about construction and demolition waste stream. Portugal was unable to present figures in response to a European Union questionnaires on this particular waste stream, because of the lack of data collected (Morgan and Argus 1995: Part 1, Appendix 5: 13).

A recent study in the Lisbon area (Procesl 1997:80) stated that construction and demolition waste production is 40% below the European average stated by Morgan and Argus (1995) and Eurostat (1997). The European average was given as 1 ton per inhabitant per year. This means that according to Procesl (1997) the construction and demolition waste production in Portugal must be around 600 Kg per inhabitant per year. This is a figure not proved in research. The last report on construction and demolition waste from European Union (Symonds et al. 1998) forecast around 350 Kg per inhabitant per year for Portugal. Silva and Farinha (1994) in a theoretical study, studying the inert extraction, the cement and iron production, estimated that in 1994, in Portugal, there was a "per capita" production of 1 tonne per inhabitant per year, of demolition and construction waste. However this estimate was not based on case study work of demolition. Instead they used existing sources of data on material used. The figures from Procesl (1997) belong to the pilot case study used in this research. Clearly further work is required to make these figures reliable.

The forecast ratio of 600 Kg per inhabitant per year in Portugal, compares with an estimate ratio of 280 Kg per inhabitant per year in Spain, as reported by the Spanish Quality and Assessment General Directorate (Dourado 1997:8). It seems unlikely that the waste trail in Spain is little more that in 25 % of that in Portugal. Therefore, there is a fundamental concern about the accuracy of the Silva and Farinha (1994) figures. The estimate from the Lisbon area study is much closer, but still double, the estimate reported from Spain. The Spanish figures are based on practical experience in a wide number of case studies. There is a need for further work, to substantiate the amount of construction and demolition waste produced in Portugal.

There are a number of other estimates of waste production for various European and American countries. Kibert (1994a) estimates that in Europe and North America almost 500 Kilograms of construction and demolition waste are generated per person each year. Swedish production of construction and demolition waste was 250 Kg per person a year (The Swedish Council for Building Research 1996:54). The World Resource Foundation report that "one US estimate suggests that five to seven tonnes of wastes are created for every new single-family house which is built" (WRF/PRISM 1997:1).

The data from the literature has been presented in Table 1.8 and demonstrates the production of construction and demolition waste in Europe. In reading this Table care must be taken to understand the limits of the accuracy of the data and also the influences the various geographic and cultural differences.

Figures in Table 1.7 are compatible with those published by The Solid Waste Association of North America (SWANA). SWANA reported construction and demolition waste generation rates, ranging from 18 Kg per inhabitant per year and 580 kg per inhabitant per year respectively (SWANA 1998).

Table 1.7 - Unit production of construction and demolition wastes in Europe

REFERENCE	PRODUCTION	BIBLIOGRAPHY SOURCE
Germany, Belgium Denmark, Holland and United Kingdom - 1990	0,8-1,0 ton/inh-year	EDA in HUMPHREYS, H (1994)
European Community - 1991	0,5 ton/inh-year	DEMEX and ISWA in MORGAN, S.T. (1995
European Community- 1991	0,4-0,8 ton/inh-year	MORGAN, S.T. (1995)
European Community - 2000	1 ton/inh-year	EEC Reward Programme in MORGAN, S.T.(1995)
Spain - 1997	250 kg /inh-year	

This data was collected from 14 references dating from 1968 to 1991. The generation rates were derived from different sources and from urban and city areas (Peng, Grosskopt and Kibert 1994). Table 1.8 displays this information.

Table 1.8 – Unit production of construction and demolition wastes in North America

Generation Rate (Kg/Person/Day)	Developed by (or for)	Source and Date of Data Used to Create the Rate
0 05	Unknown	Listed in Franklin Associates Report - 1986
0 12	California Waste Management Board for Population < 10 000	California Solid Waste Management Study- 1968 and Plan - 1970
0 18	Unknown	New York State Solid Waste Management Plan - 1991
0 22	Gershman, Brickner & Bratton, Inc.	Monterey Park, CA Source Reduction and Recycling Element - 1991
0.27	Metropolitan Planning Commission, Kansas City Region	Metropolitan SolidWaste Management and Recycling - May 1971
0.29	Gershman, Brickner & Bratton, Inc.	Town of Babylon, New York, Solid Waste Management Plan - 1991
0 31	California Waste Management Board for population from 10 000 - 100 000	California Solid Waste Management Study - 1968 and Plan - 1970
0 33	U.S Environmental Protection Agency Urban averace	Listed in Franklin Associates Report - 1970
0 34	Unknown	New York State Solid Waste Management Plan - 1991
0 62	California Waste Management Board	California Solid Waste Management Study - 1968 and Plan - 1970
0 65	Unknown	New York State Solid Waste Manacement Plan - 1991
1 25	Boston, MA	D G. Wilson, "*The Treatment and Management of Urban Solid Waste*" - 1972
1 56	Wayne, NJ	Quad City (N.J) Solid Waste Project Interim Report - 1968
1 60	Washington, D C. for 1968	D.C. Solid Waste Management Plan Status Report - 1970

Source: Peng, Grosskopt and Kibert 1994.

This approach to estimating construction and demolition generation based on per capita multipliers, has been criticised by Yost and Halstead (1996: 454). They point out that the wide variation in the figures creates very little confidence in the resulting estimates. They suggest a methodology based on the financial permits for a variety of types of construction projects. This information is drawn from a detailed and widely available database from the U.S. Census Bureau. In this way, they suggest estimates reflect actual construction activity more closely. A study replicating the methodologies has commenced in the Lisbon area, but data is not yet available.

In summary, Portugal is one of the least developed countries in EU, but it has been assumed by the European Union that significant efforts have been made by Portugal to achieve European Union levels of development. There is limited information and data about the construction and demolition waste stream in Portugal. This thesis will address some of the information needs that exist.

SECTION 5: THESIS STRUCTURE

The thesis has 10 Chapters, and four main parts. These parts correspond to different but sequential components of the research.

Part one covers chapter 1 to 5. Chapter 1 focuses on the key concepts underlying the research. The justification of the research in the context of the sustainability agenda is explained. Chapter 2 covers in some detail the concepts and principles of sustainability, sustainable development and waste management. In Chapter 3 sustainable construction is discussed in the context of the international and European construction industry. Chapter 4 discussed the features of sustainable construction and demolition waste minimisation. Chapter 5 relates to the debris trail in the deconstruction process.

Part Two covers Chapters 6 and 7. Chapter 6 links this information from the previous Chapters to possible methodological approaches. Chapter 7 reports on international case studies and experience of technical and scientific organisations in the waste stream.

Part Three focuses on the fieldwork and case study. Chapter 8 describes the Portuguese experiences that can contribute to a better understanding of the Lisbon area case studies and the difficulties in the practical development of the conceptual model.

Part Four answers the six research questions. Chapter 9 develops the model of the relationship of the waste stream resulting from the construction and demolition process. Finally Chapter 10 presents the findings of the research including a construction and demolition tool of estimating and assessment, and a proposed new strategy for dealing with this particular waste stream for Portugal.

CHAPTER 2:

KEY CONCEPTS AND PRINCIPLES

"Those who are poor and hungry will often destroy their immediate environment in order to survive: they will cut down forests; their livestock will overgraze grasslands; they overuse marginal land; and in growing numbers they will crowed into congested cities"

(WCED 1987:28)

INTRODUCTION

This Chapter is focused on key concepts and principles which are the basic support of this research. This Chapter contains four sections. Section one considers the concept of sustainability, its definition and relationship with the sustainable development concept. The key principles of sustainability, the social and political, as well as the environmental issues and growth are also studied. Section two deals with sustainable development indicators and the European framework for sustainable development. Section three discusses the waste and sustainable development. Section four discusses the integrated and sustainable waste management, the society and community participation, as well as the European overview and recent trends.

SECTION 1: SUSTAINABILITY

This section of the Chapter will discuss the definition of sustainability. The key principles of sustainability will be detailed. A discussion of some of the more important principles will follow.

Defining Sustainability and Sustainable Development

There has been a long, on going debate about the definition of sustainability. The definitions of sustainability often revolve around the author's worldview (Turner 1993). Different worldviews make different definitions and debate almost inevitable, and often incompatible (Turner 1993). The situation is further confused by the debate about sustainable development versus sustainability.

Sustainability is a complex concept. There are also a number of related concepts such as sustainable development, sustainable construction and waste management. It is necessary to explain this concepts as a background to the research. Throughout this thesis these concepts underlie the discussion and findings of the research. This Chapter covers: the definition of sustainability and key principles:

- The definition and key principles of sustainable development

- Indicators of sustainable development

- An introduction to sustainable construction

- The definition and key principles of waste management

- A discussion of waste in the historical context in Portugal

A number of definitions of sustainable development have been proposed such as:

"Sustainable development – development that is likely to achieve lasting satisfaction of human needs and improvement of the quality of life" (Allen 1997:23). For Goodland and Ledoc (1987) "Sustainable development is here defined as a pattern of social and structural economic transformations (i.e. "development") which optimises the economic and social benefits available in the present, without jeopardising the likely potential for similar benefits in future.

A primary goal of sustainable development is to achieve a reasonable (however defined) and equitably distributed level of economic well-being that can be perpetuated continually for many generations." "... Sustainable development implies using renewable natural resources in a manner which does not eliminate or degrade them, or otherwise diminish their usefulness for future generations.... Sustainable development further implies using non-renewable (exhaustible) mineral resources in a manner which does not unnecessarily preclude easy access to them by future generations....

Sustainable development also implies depleting non-renewable energy resources at a slow enough rate so as to ensure the high probability of an orderly societal transition to renewable sources ..." (Goodland and Ledoc 1987).

Some definitions or interpretations have been criticised as too vague or even ambiguous (Mitchell 1997:29). Also Wood (1994) states that sustainable development has attracted both criticism and support as well.

Dovers and Handmer (1992) recognised that the concept contains some paradoxes, tensions and conflicts. In particular such definitions could be used to support traditional capitalistic systems with their emphasis on growth. There is considerable discussion over whether growth can be sustainable in any circumstance. The Brutland Commission was explicit that while growth is essential to meet basic human needs, sustainable development involves more than growth. It necessitates a change in the nature of growth, to make it less material and energy-intensive, and to make it more equitable in its impacts. (Mitchell 1997:26). The economist Herman Doyle clarifies the difference by defining "growth" as an increase in size through material accretion while referring to "development" as the realisation of fuller and greater potential. In short, growth means getting bigger while development means getting better (Wackernagel and Rees 1996:33).

The concept of sustainable development was popularised from the report "Our Common Future" (WCED 1987). This report is also known as the Brundtlant Commission Report. Its chair was Ms. Gro Harlem Brundtland, then the Prime Minister of Norway. In December 1983, the Secretary General of the United Nations invited the Prime Minister to conduct an inquiry and prepare a report to provide a global agenda for change. Considerable discussion has derived from one short statement in the Brundtland Report (WCED 1987), the Sustainable Development definition:

"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Within this statement, there are three concepts that require more precise definition.

They are development, needs and future generations (Blowers 1996). Other authors such as Bruce Mitchell in the book "Resource and Environmental Management" (Mitchell 1997:27) have added another concept. That concept is the earth capacity to meet the needs. This concept takes into consideration the limitations created by technology and social organisations.

As Wackernagel and Rees (1996) argue despite agreement on the concept, there is no general agreement on the policy implications of the concept. One thing is certainly true, existing consumer lifestyles threaten the environment and nature and also threaten geopolitical stability. Unsustainable population increases and growing resource hungry lifestyles are the norm (UGT 1993).

Transnational consumerism and the globalisation of production and trade (Santos 1994) highlight the real necessity for a global consumer policy, in the context of the sustainability concept. The Mastrich Treaty of the European Union addresses these issues (Nunes 1994:97). Additionally the increasing economic gap between rich and poor countries (PNUD 1998) does not facilitate the move towards sustainability.

In this thesis, sustainable development can be considered to be development linked with economic growth, sustainable growth that allows human needs to be met fairly within the resources of our planet. This sustainable growth will be a growth without growing beyond the ecological carrying capacity. This carrying capacity is conventionally defined as the maximum popularisation size of a given species that an area can support without reducing its ability to support the same species in future (Wackernagel and Rees 1996:158). In short there are conditions where growth is sustainable but there is a limit beyond which growth will not be sustainable. That was the central thesis of Meadows, Meadows and Randers (1972).

Having established a working definition of sustainable development and a basic understanding of sustainability, it is necessary to discuss the principles of sustainability.

Key Principles of Sustainability

A view of sustainability, is that of a concern about the future of the earth in terms of the needs of humans, and ability of the earth resources to meet those needs. Sustainability within that view is a simple concept: it means living in material comfort and peacefully with each other within the means of nature. Despite this seeming simplicity, however, there is no general agreement on the policy implications of the concept (Wackernagel and Reeds 1996:32). In the Brundtland Report, sustainability is defined as meeting the basic needs of all people and extending to all the opportunity to satisfy their aspirations for a better life.

Another view on the nature of sustainability is contained within the Gaia hypothesis (Lovelock 1988). The hypothesis posits that the biosphere modifies itself to maintain its continued existence. It is implicit in the hypothesis that this may not include conditions for the continual existence of humankind. This position on sustainability is not pursued further in this thesis.

Several authors have developed the principles and practices of sustainability. Robinson et al. (1990:44) points out that the application of technology has allowed an improvement in the standard of living of many people around the world. However some societies have become very dependent on technology. This has also led to increasing resource consumption and production of wastes. The role of technology, education, development and culture are different in different societies. However, they tend to be interactive and complementary. Robinson et al. (1990:44) develop this idea within their principles of sustainability. These principles are divided into two types – environmental and ecological principles, and socio-political principles. These are identified below:

A. <u>Environmental and ecological principles</u>:

1.Protect life support systems. For example, ensuring breathable air and clean water.

2.Protect and enhance bio-diversity. For example ensuring the retention of wild life habitats to prevent the extinction of wild life.

3.Maintain or enhance integrity of ecosystem, and develop and implement rehabilitative measures for badly degraded ecosystem. For example cleaning badly polluted water supplies.

4.Develop and implement preventive and adaptive strategies to respond to the threat of global ecological change. For example minimising CFC's as a response to the threat of global warming.

B. <u>Socio-political principles</u>:

B1. From environmental and ecological constraints.

1.Keep the physical scale of human activity below the total carrying capacity of the planetary biosphere. For example minimising our impact on the earth. A tool to measure this – Ecological Footprint - is discussed in more detail in a later Chapter.

2.Recognise the environmental costs of human activities; develop methods to minimise energy and material use per unit of economic activity; reduce noxious emissions; decontaminate and rehabilitate degraded ecosystem.

3.Ensure socio-political and economic equity in the transition to a more sustainable society. It is clear that currently the use of the world resources is not fair. A sustainable society is likely to need a fairer distribution of resources.

4.Incorporate environmental concerns more directly and extensively in political decision-making process.

5.Ensure increased public participation in the development, interpretation and implementation of sustainable development concepts. Realistically, sustainability needs to be implemented by all people and not just a few. It is more likely that people will act sustainable if they feel involved in the strategies developed for sustainability (Robinson et al. 1990:44).

6.Link political activity more directly to actual environmental experience, through reallocation of political power to more environmentally meaningful jurisdictions. Environmental pollution does not respect political boundaries. There is little use in resolving environmental pollution in one country if the neighbouring country continues to pollute. It is necessary to take a global view and ensure that political co-operation is in place to enforce this view.

B2. From social and political criteria

1.Establish an open, accessible political process that puts effective decision-making power at the level of the government closest to the lives of the people affected by a decision. Local people know the environmental problems they face. Therefore providing them with political power and resources to resolve these problems is likely to be most effective solution. However it is recognised that some decisions need to be taken at the high level to avoid the NIMBY "not in my backyard" syndrome.

2.Ensure people are free from extreme want and from vulnerability to economic coercion. This issue was discussed in Chapter 1 and its growing importance in environmental terms is shown by the growing emphasis on action against poverty as part of environmental programmes.

3.Ensure people can participate creatively and self-directly in the political and economic system.

4.Ensure a minimum level of equality and social justice, including equality to realise one's full human potential, recourse to an open and just legal system, freedom from political repression, access to information, effective access to information, and freedom of religion, speech and assembly."

A third key principle from Robinson et al.'s work is recognising the environmental costs of human activity. A number of these points will be discussed further below.

Social and Political Principles

One of the social and political principles is incorporating environmental concerns into political process. This issue has become a priority at United Nations level as well among nations where an increasing degree of information, education, public participation and awareness of environment issues is taking place. The United Nations Conference at Stockholm in 1972 (MHOP 1978) was the world's first step in this direction. It was a real contribution to finding a new attitude to future sustainable development within the political process. In 1993 in Portugal, a National Commission for the Environment was set up. This was the first public body with environment and nature protection objectives.

Another principle is related to public participation in the environmental process. Concerns related to environmental issues are becoming a reality in today's society and also in the construction industry. This is not only due to higher education levels and more information in these areas, but also due to more sensitivity about environmental issues and increasing awareness of the need to involve the community. The growth of qualitative information is also a positive factor, which contributes to the effective involvement of the public in the decision making process.

Within the area of environmentalism, there are a huge range of views. The diversity of the views has been called the green spectrum. This spectrum has been studied by Cook (1995:63). Stakeholders and decision-makers have different point of views, which leads them to different behaviours in practice. An extensive literature review (Golton 1995a), revealed that the "green spectrum" could be classified in five groups as presented in Figure 2.1.

Figure 2.1 – The Green Spectrum

<table>
<tr><th>Transpersonal Ecology</th><th>Deep Ecology</th><th>Moderate Ecology</th><th>Accommodation Environmental</th><th>Comucopian Enviromentalism</th></tr>
<tr><td>population cull</td><td>reduce population</td><td>zero population growth</td><td>silent</td><td></td></tr>
<tr><td>resource preservation</td><td colspan="2"></td><td>resource</td><td>resource</td></tr>
<tr><td colspan="3"></td><td colspan="2">anthropocentric</td></tr>
<tr><td colspan="3">capitalism is unsustainable</td><td colspan="2">capitalism is sustainable</td></tr>
<tr><td colspan="4">lacks faith in technology</td><td>faith in science technology</td></tr>
<tr><td colspan="3">recycle after re-use and</td><td colspan="2">recycle</td></tr>
<tr><td></td><td>heavily regulated economy</td><td>zero economic</td><td>managed growth</td><td>maximise growth (GNP)</td></tr>
<tr><td colspan="2">very strong sustainability</td><td>strong sustainability</td><td>weak sustainability</td><td>very weak sustainability</td></tr>
</table>

Source: Golton 1995a.

Different people with different responsibilities will be involved in environmental programmes. Those participating include public administration and local authorities as well as research organisations, institutes and universities. The ordinary person is also likely to be involved with the implementation of some environmental programmes, even if they are not extensively involved in the design of those programmes.

It is important that all those involved should have a clear perception of the environmental responsibility that everybody within the community must assume. Sustainability and sustainable development can only be achieved if the community is informed and prepared to change their attitudes and behaviours. The European Union is very concerned about public access to environmental information in order to inform and hopefully change attitudes. Directive 90/313/EEC deals with this issue and is part of a fundamental move towards a greater transparency in policy (EEA 1997a: 22).

Environmental Impact of Human Activities

Recognising the environmental cost of human activities requires recognition of environmentally significant consumption. Resource consumption has been steadily growing and in these last decades it has become clear that it will be necessary to develop empirical analysis into two areas of concern (Stern et al. 1997:2). One is the area of specific human choices and actions which are most responsible for adverse changes in the biophysical environment. The other, following from that, is concerned with influencing those choices or options and actions to minimise the threats to the environment.

There has been a long debate dating from 1970 about the relationship between environmental impacts, population growth, resource consumption and industrial expansion. This relationship was expressed by Holdren and Ehrlich as early as the 1970's (Holdren and Ehrlich 1974:62: 282-292) and conceptualised as the equation:

$$I = P \times A \times T$$

In this equation, I represents environmental impact, P represents population and A economic output per capita, usually interpreted as a measure of affluence. T is the environmental impact per unit of economic output, sometimes interpreted as a characteristic of technology.

There are many debates about this equation. Most authors accept the general equation however and the debate focuses on the exact relationship between the variables. This is because there is interdependence and a dynamic relationship between these variables, which means they need special mathematical treatment. Some authors, such as Dietz and Rosa (1997:92) have proposed the mathematical reformulation of the classical IPAT relationship to a stochastic model such as:

$$I = a\,P_b\,A_c\,T_{de}$$

In this model, a, b, c and d can be either parameters or more complex functions. They can be estimated by using statistical procedures. The residual term, e, represents all variables not explicitly included in the model.

In the context of construction when dealing with the structural impacts issues, the IPAT expression was restated by Golton and Frost (1993:63) as follows:

Impact = Population x Consumption (I = P C) and

Consumption = Affluence x Technology (C = A T)

The authors explained that the first equation highlighted the multiplier effect of population, while the second statement highlights the relationship between consumption, affluence and technology. Golton (1995b:63) developed a conceptual model of life of building, where the building life is studied in its relationship with the process and activities which create impacts and dynamic which drive the frequency with which the impact producing processes occur.

Capacity Building

To successful implement any of the sustainability principles requires recognition of the countries' capacity building. A country's ability to follow the path to a sustainable society is determined, to a large extent, by its endogenous capacity to make independent and equitable decisions compatible with sustainable development – the country's capacity building. A country's capacity encompasses the human, technical, organisational, institutional and resource capabilities to choose and implement actions and development options.

Capacity building involves strengthening national capabilities for design and implementation of commodity policy, use and management of national resources, and the gathering and utilisation of information on commodity markets. The sustainable development must take account of needs, priorities, variables, existing strategies and have a dynamic perspective. The ability of a country to achieve these objectives, its capacity building, is a concept found throughout Agenda 21 (UN 1992a). There is a very clear premise that human society is a subsystem of the ecosphere, in a dynamic process with an environmental load, which can destabilise the natural system.

A significant contribution to this capacity building agenda are the NGOs' participation. A key barrier to achieving sustainable development is the lack of capacity (awareness, skills, infrastructure and resource) at the national and local level. This leads to the limited participation of stakeholders and a lack of partnership between government, private sector and NGO communities. Since 1992, there has been broader discussion and debate amongst governments, aid agencies and NGOs community of building-capacity as both a "foundation" and a "value adding" strategy. The role of NGOs in facilitating and delivering capacity-building planning and programmes has been increasingly appreciated. The interest of donor agencies and international NGOs in capacity development planning and community development processes, and in the interface between environment and development aid, has also increased (WWW 1997:13).

Poverty together with economics systems, social constraints and lack of education have established themselves as barriers to improving sustainable development. This is particularly the case when dealing with hazardous and toxic wastes (UN 1992a:186- 214). Capacity building within any county must address these issues.

Growth and Sustainable Development

Development is often confused with growth. Growth is a quantitative concept concerning the physical expansion of the economic and other systems. Development is a qualitative concept, incorporating notions of improvement and progress, and including cultural and social, as well economic dimensions (Wackernagel and Rees 1998).

If all the world population had the same lifestyle as the USA population, we would need eight Earth planets to satisfy the consumption of natural resources associated with that lifestyle (Wackernagel and Rees: 1996). How is it possible to minimise the extraction of natural resources, to lessen energy consumption, to adopt sustainable attitudes, to increase the reuse and recycling of construction materials if there is not a clear national strategy to achieve these objectives?

The reality is that today the world is aware of the need for both economic development and a respect for the environment and nature. The aim must be to achieve an environmental and ethical view where the human being is at the centre of our existence and to contribute to diminishing the gap between rich and poor countries (UN 1997b).

Making environment issues compatible with economic development is more significant nowadays in comparison to the 1970's (Pecci 1981). The 1972 book entitled The Limits of Growth (Meadows, Meadows and Randers 1972) addressed this issue. The objective was to illustrate the necessity of improving a real human understanding in respect of the environment and nature. The model developed some economic and environment scenarios. Some of these scenarios were pessimist but others were optimistic and realistic. All of them demonstrated practical possibilities for implementation under real conditions. The forecasts made by the Meadows team later received sharp criticism (Meadows, Meadows and Randers 1991). Some of these criticisms were justified and accepted as the work presented scenarios and perspectives which had not been carried through to final conclusions.

The large population and high standards of living of some countries, which many more counties wish to emulate, have raised the question of whether such a position is sustainable by the earth's environment. The definition widely accepted for 'development' is based on growth in production of commodities for a profitable sale and highlights that concern. Must we redefine development to sustainable development in order to survive? (Johnson 1989:196). The definition of sustainable development posited in the Brundtland Report in 1987 has achieved widespread popularity and directly addresses the issue of future growth: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). Realistically, the success of environmental polices within capitalism, whether of the "green consumerism" type or others may depend not only on legislation and regulation, but also on the discovery of alternative ways of making profits.

The growth concept in the development definition is probably inherent to a capitalist society, as a way towards economic development (Johnson 1989:102). It is the dichotomy between 'growth', at the heart of economic sustainability concepts and 'no growth', at the heart of environmental sustainability concepts which has to be resolved.

O'Riorden (1981) identified four precepts that need to be meet in order to achieve sustainable development as opposed to a traditional development. They are:

(1) That it is possible scientifically to "know" the rates at which resources are renewed, so that their management can be geared to those rates.

(2) Those renewed resource systems can operate homeostatically, so that if we manage them correctly equilibrium will be maintained.

(3) That the implication of drawing on a resource are constrained to the tight ecosystem of which it is a part.

(4) That using a resource up to the level of renewability is ethically justifiable.

O'Riorden goes on to argue that none of those principles is realistic, practicable or justifiable. In doing so, he separates the first two precepts, which are statements of the scientific possibility of sustainable utilisation of resources, from the other two, which are concerned, with the ethical issues of sustainability. The former is necessary for the latter. If sustainable utilisation is feasible (the first two precepts), then sustainable development becomes a managerial and political goal. But as he points out, sustainability is a much broader phenomenon. It embraces ethical norms pertaining to the survival of living matter. It includes the rights of future generations and institutional responsibility for ensuring that such rights are fully taken into account in policies and actions (O'Riorden 1981).

The human use of raw materials, with the exception of timber, was almost insignificant until the rise of the Industrial Revolution in the 19th century. From that point "increases in mineral consumption were particularly sharp. Geologist C.K. Leith wrote in 1927, that in the last hundred years the output of pig iron has increased 100 fold, of mineral fuels 75 fold, and copper 63 fold. In the last fifty years the per capita consumption of materials in the United States has multiplied fifteen times. The world has exploited more of its mineral resources in the last twenty years than in all preceding history" (Worldwatch Institute 1991:7).

The Rio Declaration on Environment and Development (UN 1992a), the Earth Summit, with its 27 principles for sustainable development, gives an idea about the constraints and difficulties in answering this challenge. The principal outcome of the Earth Summit is Agenda 21, an Action Plan for the 1990's and into the 21st century. Agenda 21 is a blueprint for action, for global sustainable development into the 21st century. It contains strategies, integrated programmes and measures to halt and reverse the effects of environmental degradation. It promotes environmentally sound and sustainable development in all countries. Agenda 21 is based on the premise that sustainable development is not just an option but an imperative, in both environmental and economic terms, and while the transition towards sustainable development will be difficult, it is entirely feasible. It requires a major shift in priorities for governments and people, involving the full integration of activity and a major re-deployment of human and financial resources at national and international levels. The changes must be based on a new understanding of the impact of human behaviour on the environment.

There is an on-going debate about the means of achieving sustainable development and the sustainability criteria. An appropriate strategy for sustainable development in this context must link sustainable development with the economic situation. In this context the concerns of United Nations must be highlighted. For example, in Section 1 (Social and Economic Dimensions) of Agenda 21 the United Nations seeks "international co-operation to accelerate sustainable development in developing countries and related domestic policies" (UN 1992a:17). Included in this are policies relating to combating poverty; changing consumption patterns; demographic dynamics and growth; protecting and promoting human health; promoting sustainable human settlement; developing and integrating environmental concerns in the decision-making process (UN 1992a:17).

The three others sections on Agenda 21 (Conservation and Management of Resources for Development, Strengthening the Role of Major Groups and Means of Implementation) give a clear idea, that humanity today is in the midst of a profound societal change. There is much to be done. In this sense, the world is "in our hands" (UN 1992b: Foreword).

Curitiba (Brazil) with significant financial support from the World Bank and the United Nations could be a very important example of a social, economic and environmental sound iniative. Curitiba is a Brazilian city of about 2 million people located on the Atlantic Coast about 250 Km Southwest of Rio de Janeiro. The World Bank uses it as an example of what can be done through civic leadership and public participation to clean up the urban environment. Curitiba has acquired a world-wide reputation for its innovative urban planning, and environment protection practices. The heart of Curitiba's environmental Plan is education for both children and adults. The city has successfully instituted a complex recycling plan that requires a careful separation of different materials. Poor and unemployed people undertake this work voluntarily and were the main actors in this sustainable and integrated waste management process (Cunningham and Saigo 1995: 558).

The concept of sustainable development and its applications in the developing countries' economies, specifically applied to those weak economies in a world context, were studied and highlighted by Pearce (1993). The social context where sustainability can be achieved was stressed in a work entitled the "Social Dilemma from Agenda 21 and its local application" (Hodgson 1996). This call for sustainability and the need of sustaining this revolution is the greatest challenge. Addressing these concerns, and in a contribution to global information, UNEPE (UNEPE 1995) presented a guide to the world's communities, to follow the Agenda 21 principles and objectives.

Summary

The literature reveals significant debate around sustainability concepts and principles as compared with sustainable development concepts. The concept of development needs to be seen as qualitative, not quantitative, in order to clarify a process towards sustainability (Wackernagel and Rees 1996:33). Overall economic, social and political issues are shown to be interrelated with environmental issues and impacts of human activities. This is particularly important with respect to resource consumption (Dietz and Rose 1997). The impact of growth on the environment is enhanced by its multiple interactions across the issues.

SECTION 2: SUSTAINABLE DEVELOPMENT INDICATORS

In order to properly understand sustainable development we have to measure it. There are a number of possible indicators relating to sustainable development. This section considers a range of those indicators that are relevant to construction.

It is fundamental to have targets and indicator systems to evaluate progress. Good policy making depends on good information about the problems, their magnitude, their causes and the success or otherwise of present policies in dealing with them. On the output side, indicators can relate to emissions to air and water, noise, generation of solid waste and hazardous substances among others. On the input side, indicators relate to resource extraction and consumption, energy consumption, materials consumption, growth of built up land and many other indicators.

An important contribution to this knowledge, in environmental indicating at international level, is the "Core Set" of indicators of development by the OECD (OECD 1994). This set, includes 72 indicators in all but only 30 are yet operational. They are classified in two ways: according to the issues to which they relate, and as indicators of either "pressures", "states" or "responses". "Pressures" indicators may for instance be polluting emissions, "state" may be air or water quality, and "response" may be expenditure or cleaning measures.

Within the 5th European Union Environmental Action Programme, the European Environmental Agency has been involved in defining 84 indicators. These indicators show the European Union share of world population, energy and minerals consumption. They emphasis that there is still a considerable amount of work to do to present consumption targets based on global equity (EEA 1995:33).

The EUROSTAT (Eurostat 1997) has an important role in co-ordinating work on the development of an "Environmental Pressure Index" (EEA 1998a). This will be aggregated from indicators from 10 identified "problem areas" of which "resource depletion" has been recognised as one of them. However, the specific indicators in this area have yet to be identified.

Since the United Nations Conference on Environment and Development held at 1992, several proposals have been advanced at international level for more comprehensive sets of "sustainability" or " sustainable development" indicators. These have a narrower focus than the environmental indicators. Indicators proposed by the United Nations and those proposed by the World Wide Found for Nature (WWF/NEF

1994), in co-operation with the New Economist Foundation, consists of a large number of indicators on human development and welfare.

Sustainable development indicators, are necessary for decisions on different levels and in different areas. Various initiatives and projects developments throughout the world have emerged with the objective of defining sustainable development indicators, not only for broad management solutions at a national level, but also at a regional and local level (Cummings and Cayer 1993). One objective of the United Nations Commission on Sustainable Development (UNCSD) is the creation of a global framework of indicators. The framework could ensure the technical validity, the comparison and the acceptance of these type of indicators (Gouze, Mazinng and Bilhaz. 1995). The use of this type of agreed indicators have been gaining support among the research community, which has to utilise, treat and transmit technical and scientific information: Agreed indicators make it easier to utilise existing data by decision-maker, managers, politicians, interest or pressure groups, technicians, scientists and the public in general.

At international level there are different organisations developing work in this area, including the European Environment Agency, the Organisation of Economic Co-operation Development (OECD), the United Nations Environment Programme and the USA Environment Protection Agency.

The United Nations Commission on Sustainable Development (UN 1996) proposed a working list of indicators of Sustainable Development as follows:

- Indicators for social aspects of Sustainable Development

- Indicators for economic aspects of Sustainable Development

-Indicators for environmental aspects of Sustainable Development

- Indicators for institutional aspects of Sustainable Development

There are some groups working on sustainable development indicators in Portugal. These studies relate mainly to the urban environment quality (Partidário 1990) and to coastal water quality control (Ramos 1996).

There are various applications of sustainable development indicators that can be useful.

Applications of Sustainable Development Indicators

Sustainable development indicators as Ott (1978) points out, could have a significant amount of practical application. He identifies a number of applications (Ott 1978) as follows:

- Resources attrition – Indicators can help the decision-makers or managers in funds application, natural resources allocation and priorities.

- Site classification – Indicators can allow comparisons between different site and geographic areas.

- Legal regulation observances – Indicators can clarify and syntheses the level of legal regulations required.

- Tendency analysis – Indicators can be used to detect time and space tendencies, with special attention to analysis that is easy to interpret.

- Public information – Sustainable development indicators support the public information processes.

- Scientific research – Indicators can provide scientific development with the information about areas to develop further and deeper scientific studies into specific situations.

The OECD (1994) also identifies four wider areas for application of the indicators.

- Environmental systems operation assessments

- Environmental issues concerning consideration in sector policies

- Environmental accountancy

- Environmental state report

According to Ramos, Rodrigues and Gomes (1998:17) these wider areas and information from them are fundamental for good policy-making. This means that it is important to know the problems, their magnitude, their causes and the success or otherwise of present policies in dealing with them.

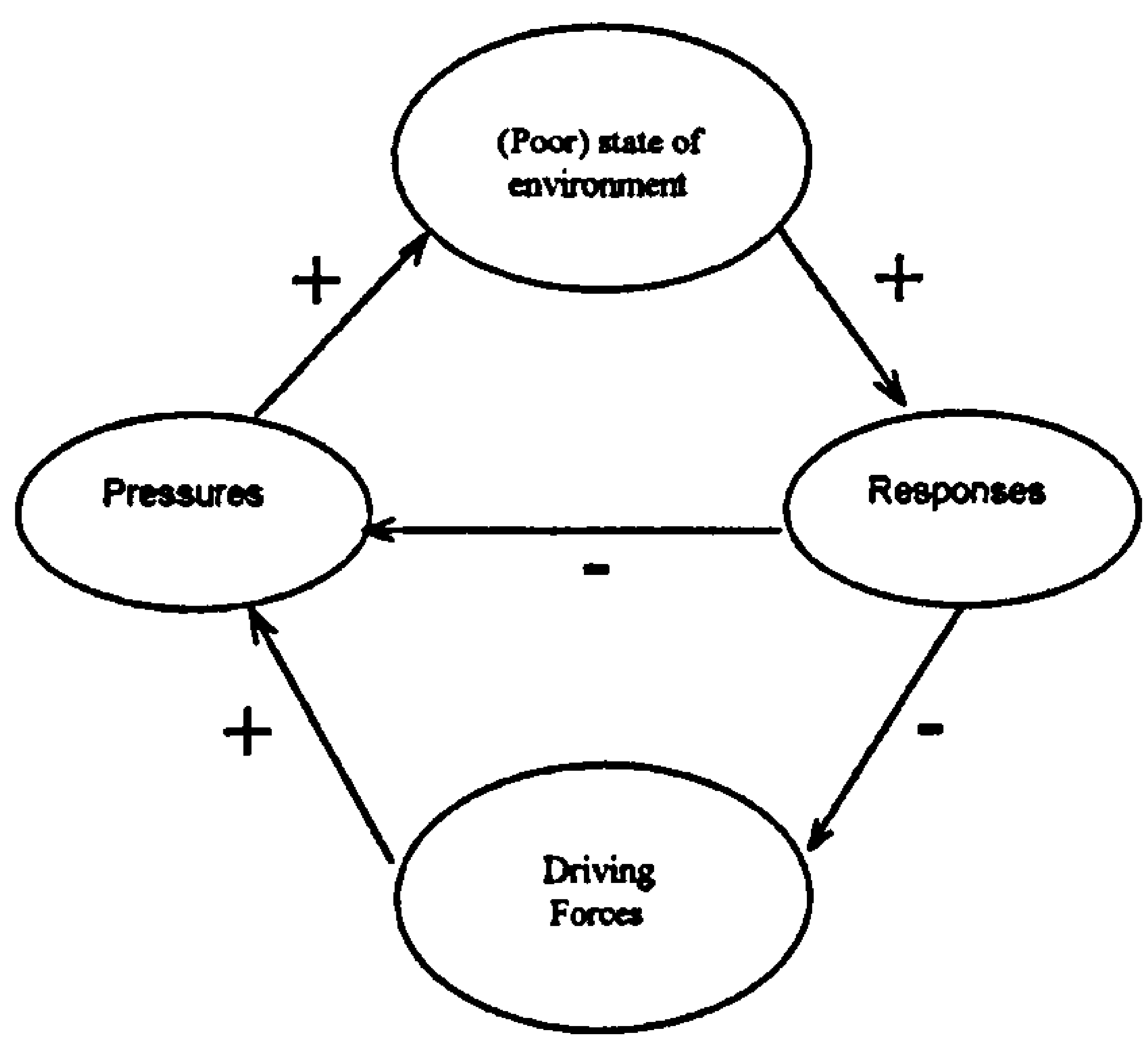
However there is also a three way classification of indicators called Pressure-State-Response (PSR) which has gained wide acceptance (OECD 1994). In this model, the terminology "Pressure" refers to indicators that relate to impact and problems such as pollution emissions. They are pressuring the environmental system. "State" refers to indicators relating to the current position for example air or water quality. "Response" relates to indicators associated with remedial actions to deal with environmental problems (EEA 1998a:35).

More recently the United Nations and the EEA has been developing models with terms such as "driving forces" and "braking forces", and interrelationships more adapted to the practical world. For instance, increasing recycling rates may be interpreted as a "Response" leading to less primary materials consumption. Decreasing or static recycling rates may be regarded as a " driving force" or pressure for the level of the consumption.

Figure 2.2 is a simplified illustration of the relationships between driving forces, pressures, state and responses. Ideally responses should lead to reduce pressures, either directly if the responses are of the "end of pipe"[1] or indirectly by dampening the driving forces.

The application of these models and indicators to Portugal was developed first by the General Directorate of the Environment (DGA), in a document currently under public consultation (Ramos, Rodrigues and Gomes 1998).

Figure 2.2 – Relationship between driving forces



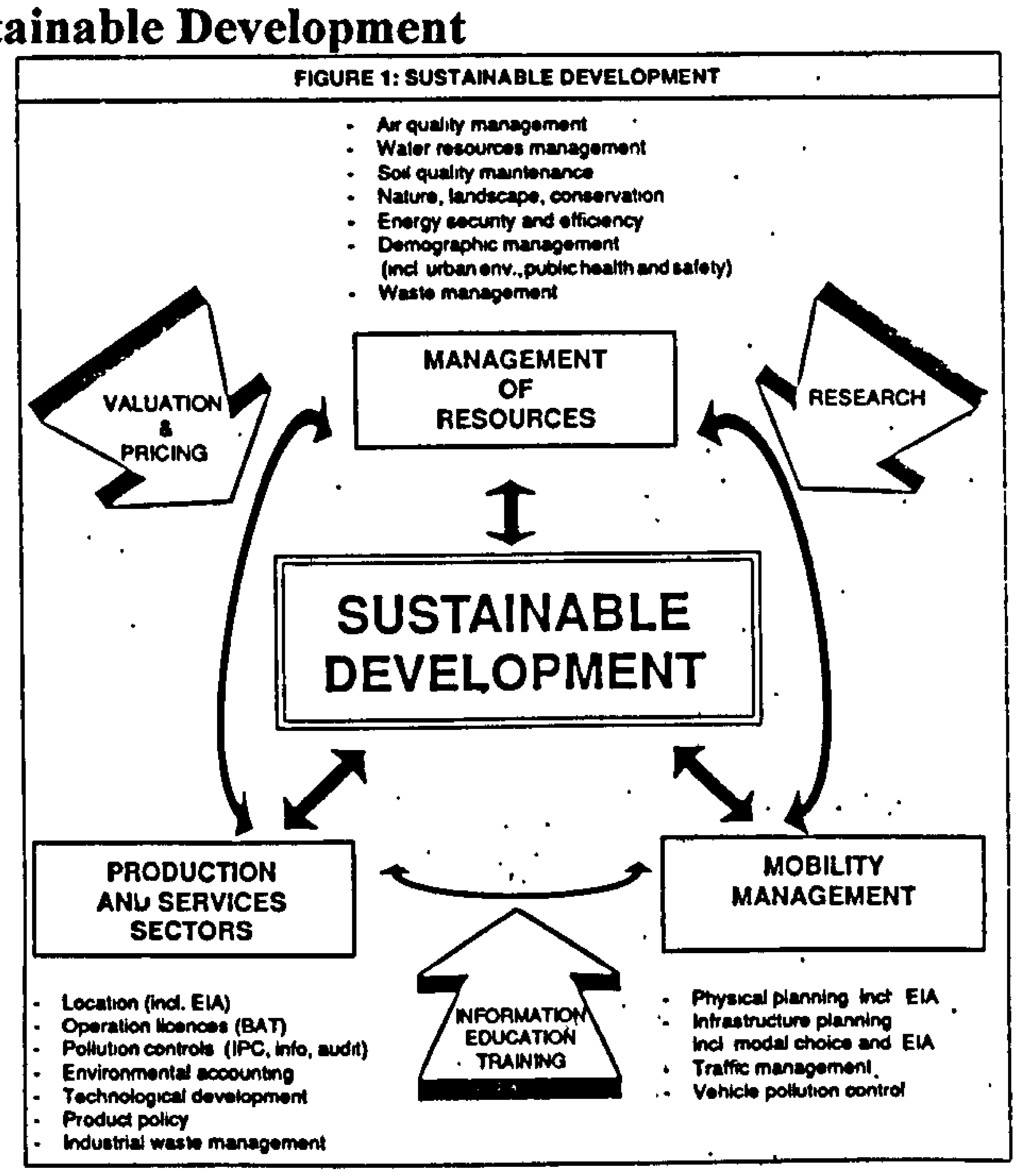
Source: EEA 1998a:35

[1] "End of pipe" technologies are technologies not concentrated on environmental and prevention attitudes, effiency and perfomance, needing expensive treatment of their emissions (Barratt 1996).

The European Framework for Sustainable Development

As the World Commission on Environment and Development stated in 1987, "Those who are poor and hungry will often destroy their immediate environment, in order to survive: they will cut down forests; they livestock will overgraze grasslands; they will overuse marginal land; and growing numbers they will crowd into congested cities." (WCED 1987). The European Union is also attentive to this statement, and its Fifth Programme on Environment and Development reflects these concerns. The Fifth Programme from the European Union on the Environment and Sustainable Development "Towards Sustainability" (EC 1992b), had a global objective for the continued support of all citizens with political, economic and social interventions within a Sustainable Development framework (see Figure 2.3).

Figure 2.3 - Sustainable Development



Source: EC 1992b, Fig. 1.

Europe needs a new emphasis on prevention rather than cure. Although the fifth programme did relate to prevention, this aspect must be strengthened. There was a significant difference between the previous four programmes, which focus on treatment and the fifth, which focus more on prevention.

The framework presented in Figure 2.3, must be put in practice with Programmes, Plans and Actions, according to the global dynamics of the overall systems, and where the present and the future of mankind, must be the main goal. In the context of this research, the prevention is seen as the need to reduce the generation of waste in a waste and integrated management policy. This position is highlighted in the work of Haq and Artola (1996). An interim report from the European Union, under the title "The European Union Environmental Policy on the Threshold of the XXI Century" reviews the main concerns and the challenges in the environmental area, with special stress on waste management (EC 1996a).

As a consequence of these concerns, and in order to apply the Agenda 21 recommendations, the European Union developed an assessment with United Nations collaboration called "Dobris Assessment" (EEA 1995) in 1994. Its objective was to make the environmental analysis bases available to those who develop work and have responsibilities in the environmental area. Obviously this includes information to industry and its participation and involvement in achieving the targets and goals of the Fifth Programme (EEA 1998b). In 1997, the European Union published a document where it stressed the deeper concerns with the environment in its different perspectives (EC 1997b). A second environmental assessment in Europe (EEA 1998b) was undertaken by the European Environment Agency. The objective is to update the information and data for the next Programme to be presented in 1999, as the European Union Programme for the new millennium.

More specifically, the terms of reference from the General Assembly of the United Nations were:

1 – To propose a long term environmental strategies for achieving sustainable development by the year 2000 and beyond, and

2 – To identify how relationships among people, resources, environment and development could be incorporated into national and international policies.

In this work, the Commission included representatives from developed and developing countries, and held public meetings in various countries around the world. But as Andrew Blowers point out in his work (Blowers 1996: 7), there are wide contrasts and also a big gap, in the use of resources and quality of environment between rich and poor, between East and West, between North and South.

In the developing countries the struggle to survival is paramount. Poverty reduces people's capacity to use resources in a sustainable manner. It will not be an easy and safe passage into the 21st century even with the United Nation's quest for peace, equality, justice and development (Muller and Roche 1995). The authors quoting Pierre Teilhard de Chardin remember that: "Some day, when we have mastered the winds, the tides, and gravity, we will harness the energies of love. Then, for the second time in the history of the world, the human being will have discovered fire (Muller and Roche 1995)."

SECTION 3: WASTE AND SUSTAINABLE DEVELOPMENT

Waste and its role in the environmental dynamic system are central to this thesis. Waste materials are a consequence of life, and they are also fundamental to defining a sustainable way forward. The objective of this section is to present an overview of the waste problem in an historical, modern and environmental context of Portugal. There is a review of the European Community context, and a discussion of the definition of waste.

Defining Waste

There are two views of 'waste'. The traditional view is of an unwanted item, discarded in a throwaway society. Something to be removed as far away from us as possible and certainly "not in my back yard" (NIMBY) (Petts and Eduljee 1994:389). Municipal Solid wastes are defined as the wastes emanating from human and animal activities that are discarded as useless or unwanted. They include industrial waste from the burgeoning new large scale manufacturing process (Williams 1998). They are normally solids but may include liquids. This definition is relative and therefore compatible with the new ideas and trends from a sustainability point of view. What is waste, useless for one generation, may be considered useful for the next.

The alternative view sees waste as a raw material substitute with the resulting environmental advantages. Waste then becomes not a useless item, but for example a potential "fuel" in combustion operations designed to produce heat and generate stream (Diaz et al. 1993:4).

EC Directive 91/156/CEE of the 18th March 1991 contains a key definition of waste. "Waste" is defined as "any substance or object in the categories set out in Annex 1 (Appendix A) which the holder discards or intends or is required to discard". However, many people argue that this definition is imprecise and open-ended. Salter (1998) supports this view by referring to twenty-seven cases concerning community legislation on waste which still remain pending before the EC Court since at least September 12th 1996.

The definition of waste, and its importance and role in the sustainable development agenda is subject to an on going debate at European Union level and also in the OECD. An OECD meeting held in May of 1997 defined waste and non-waste (OECD 1997a). Its gives the following definition of waste:

"Wastes are materials other than radioactive materials intended for disposal, for reasons specified in Table 1". Table 1 is titled "Reasons why material are intended for disposal" and contains a list of sixteen categories of waste. The definition was necessary due to difficult with previous decisions. Article 3 (OECD 1998a) stressed the need for this redefinition. It states:

... - "3. The definition set out in the OECD Decision C (88) 90(Final) is implemented within the context of national laws and regulations. The different implementation of this definition can lead to further difficulties in achieving consistent application, particularly when materials are to be subjected to trans-frontier movements for recovery in the context of OECD Decision C (92) 39/FINAL, since different decisions are reached in different countries about the status of the same material".

The European Court of Justice, the ultimate European arbiter in the matter, has been building a jurisprudence confirming the wide coverage of the term "waste", irrespective of economic value or destination. The current position is that the waste lists, while all being relevant in the European legislation, show some discrepancies. Their wording, as in the case of the literal definition of waste itself, remains often vague. The end result is an enduring confusion around what is waste. Another issue related to the lists is that some seem to have been derived from others, but the rationale behind the development is unclear.

It is clear that the large number of lists does not contribute to the harmony of the European waste legislation (EC/IPTS 1997). It is therefore necessary to address this issue of harmonisation. The European Commission is making efforts in this direction in its attempt to harmonise the lists of the European directives with those of the Basel Convention. This work is hampered by the fact that the lists reflect the state-of-the-art of the moment when they were established. various articles to that effect present in the various European directives (EC/IPTS) refer to updating the lists but adapting them to technical progress remains a lengthy process often lacking transparency.

The OECD and the European Commission are conscious of theses problems and have been discussing the idea of proposing criteria for determining whether a material is waste. The OECD is currently carrying out a project on the definition of waste in which this theme is developed. Using a criteria based approach would have the advantage of removing the crucial importance of the lists and of their wording since any dispute could be referred to the application of the criteria. It would also have the advantage of overcoming the obsolescence issue inherent in the list approach (EC/IPTS 1997).

A study from the Institute for Prospective Technological Studies observed the legal definition of waste and its influence on waste management in Europe. The Institute is a Joint Research Centre under the European Commission organisation based in Seville Spain. The study revealed some important insights into the discussion on the definition of waste (EC/IPTS 1997). It compared the Framework Directive of wastes with other Directives and regulations, the OECD and the national definitions of waste in the European Union countries. It also studied waste lists such as the European Waste Catalogue, the list from Regulation 259/93, the European hazardous wastes list, the OECD lists and the Basle Convention lists. On 22 March 1989 the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their disposal was adopted. It was signed also by the European Community. The Convention contains basic principles on methods of identification, publication and control of transboundary movements of certain types. Recognised goals of all signatory states of the convention are waste prevention, minimisation of transfrontier movement of the wastes listed and a waste disposal consistent with the protection of human health and environment.

The goal of the study was to establish if the definitions could be developed to become harmonious and adaptable. Having analysed the main problems of the legal definition of waste and its influence on waste management in Europe, the study reported seven important recommendations as follows:

" – To keep the eyes on the broad European waste management policy objectives (i.e. environment and public health protection) and use common sense during the elaboration of all the new pieces of legislation.

- To issue European guidelines for the implementation of the European waste management policy to reduce the problems due differences of interpretation. If everybody follows the same philosophy, problems will decrease. A clear rationale behind the whole waste management policy would help actors comply with the legislation. It also would be necessary to harmonise European definitions when there are discrepancies between Directives.

- To design a European legal framework for waste management, which allows easy adaptation in time to study and develop Science and Technology, to local conditions. In particular, the building of a decision tree for the determination and classification of waste would be an important achievement.

- To reduce the legal and administrative burden, simplify legislation and increase control towards a waste policy. The European waste management legislation must be manageable.

- To apply risk assessment to the shipment and handling of waste. However, this is closely linked to the processes used, and such related to the technical state-of-the-art. Certification of facilities, processes and operators could be a way to promote and ensure the development "best waste management practices"

- To make sure the classification of a material as waste should not hamper any recovery, treatment or disposal option susceptible to providing the best possible solution using economic and environmental references, which need to be coherent.

- Clarify the distinction between waste and secondary raw materials. In its Article 3, Directive 91/156/EEC opens the door to such an approach: " Member States shall take appropriate measures to encourage the recovery of waste by means of recycling, reuse or reclamation or any other process with a view to extracting secondary raw materials". While not removing certain categories of waste from the scope of the definitions, case-by-case conditional exemptions following strict rules could be granted.

- To set up a permanent official European "Waste Forum", analogous to the "Information Exchange Forum" set up for the IPPC (Integrate Pollution Prevention Control) Directive. Ultimately this would be responsible for interpreting definition, updating the lists, ensuring an objective interpretation of the criteria for the classification of waste and performing the adaptation to technical progress. Such a forum would be composed of representatives from the European Commission, the competent national authorities, the industry sectors concerned, environmental NGO's and consumer organisations."

Clearly the adoption of these proposals would move the process of harmonisation forward. Equally clearly the difficulties will occur as the discussions focus on the detail.

The R's

As the debate on waste between environmental, social, psychological, economical and political positions has developed, a number of concepts and terms have become significant. Originally, the debate focused on the idea of Reduction, Reuse and Recycling (the three R's) . According to Tchobanoglous, Theisen and Vigil (1993), Reuse is the use of a waste material or product more than once for the same or similar use. For example, cleaning and re-use a glass jar. Recycling consists of re-processing a waste material so that it may be used again as a useful material for products, which may or may not be similar to the original. For example, the reduction to cullet of glass items so that they may be remanufactured into new articles. Reduction is about reducing the amount of waste produced. For example, reducing the amount of short life objects such as packaging and increasing the repairability of articles. This 3 R's policy is well known and disseminated in Portugal by a number of Portuguese NGO's (Quercus 1994:8).

The debate has moved onto the 4 R's with the introduction of Recovery. According to Tchobanoglous, Theisen and Vigil (1993) recovery or resource recovery is a general term used to describe the extraction of economically usable of materials or energy from waste. For example, the thermal processing[3] of solid waste, used both for volume reduction and energy recovery, is an important element in many integrated waste management systems (Tchobanoglous, Theisen and Vigil 1993:611). The concept may involve recycling or conversion into different and sometimes unrelated uses.

It is accepted that it is extremely important to become responsible and rationalise, making 6 R's (Dias et al. 1993). Responsibility is to have the control, the authority and being accountable for one's actions and decisions. Rationalisation is to apply logic or reasons to something, or to eliminate unnecessary equipment (Oxford Dictionary 1995). Both definitions in the solid waste context should contribute to a better quality management. The 6 R's are considered to be the way to achieve the integrated and sustainable waste management concept (Dias et al. 1993:267).

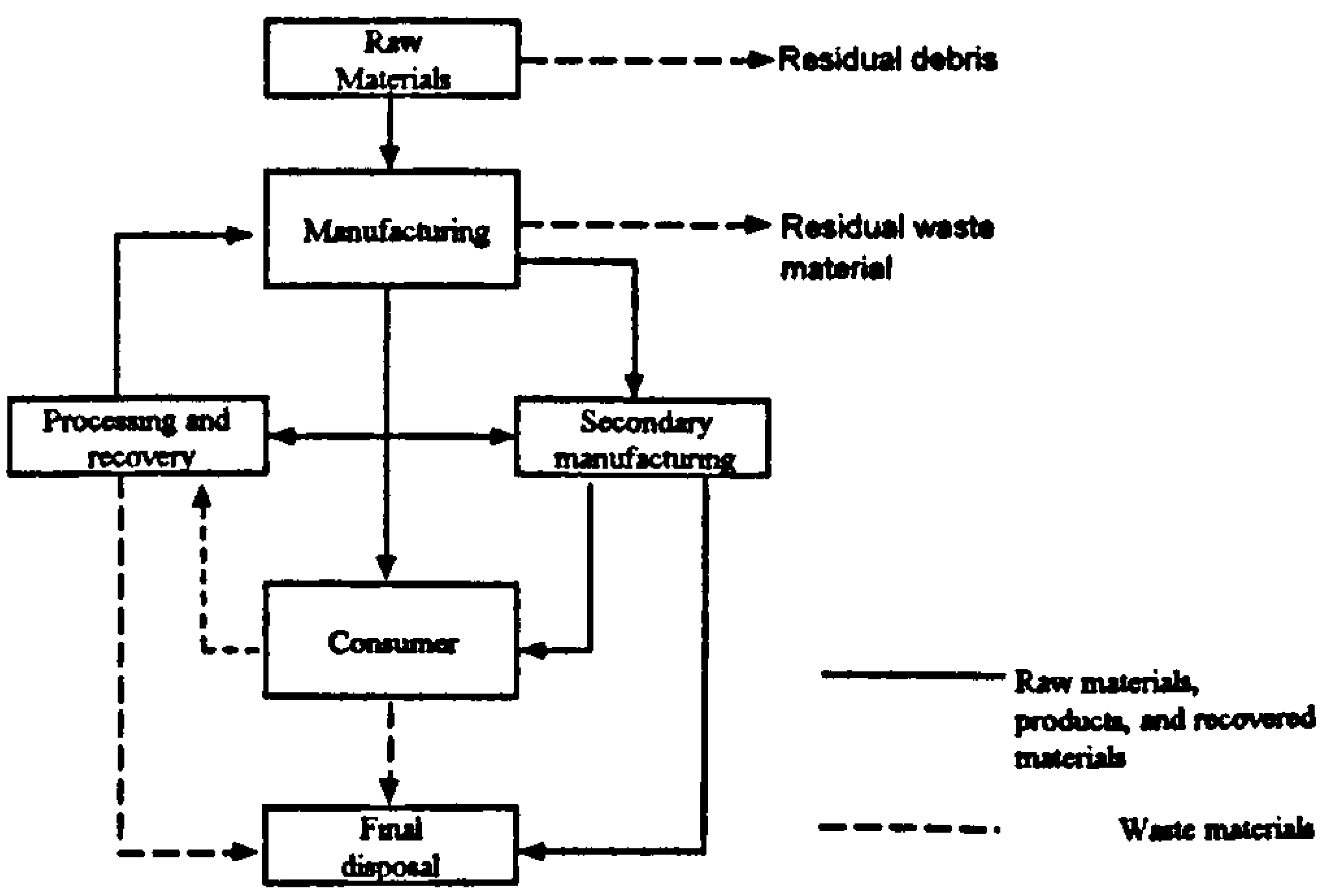
With a basic understanding of what is meant by waste and associated concepts, it is also worth considering the nature of waste in the historical and environmental context in Portugal.

[3] Thermal processing of solid waste can be defined as the conversion of solid waste into gaseous, liquid, and solid conversion products, with the concurrent or subsequent release of heat energy (Tchobanoglous, Theisen and Vigil 1993:611).

From the origins of life, humans and animals have used the resources of the Earth to support their lives and dispose of their wastes. As societies developed so did responsible ideas of pollution and health.

However, with the advance of technological-based societies, wastes are generated on a greater scale than ever before. This rate of change outstripped a responsible approach to the control of the wastes generated. Solid wastes are generated at every step of the industrial process. At the beginning, mining the raw materials leaves a trail of waste and visual pollution. Throughout the process of converting the raw materials to goods and to the point of consumption and disposal further waste is produced and excess energy consumed (Tchobanoglous, Theisen and Vigil 1993). This is shown in Figure 2.4.

Figure 2.4 - Materials flow and the generation of solid wastes in a technological society



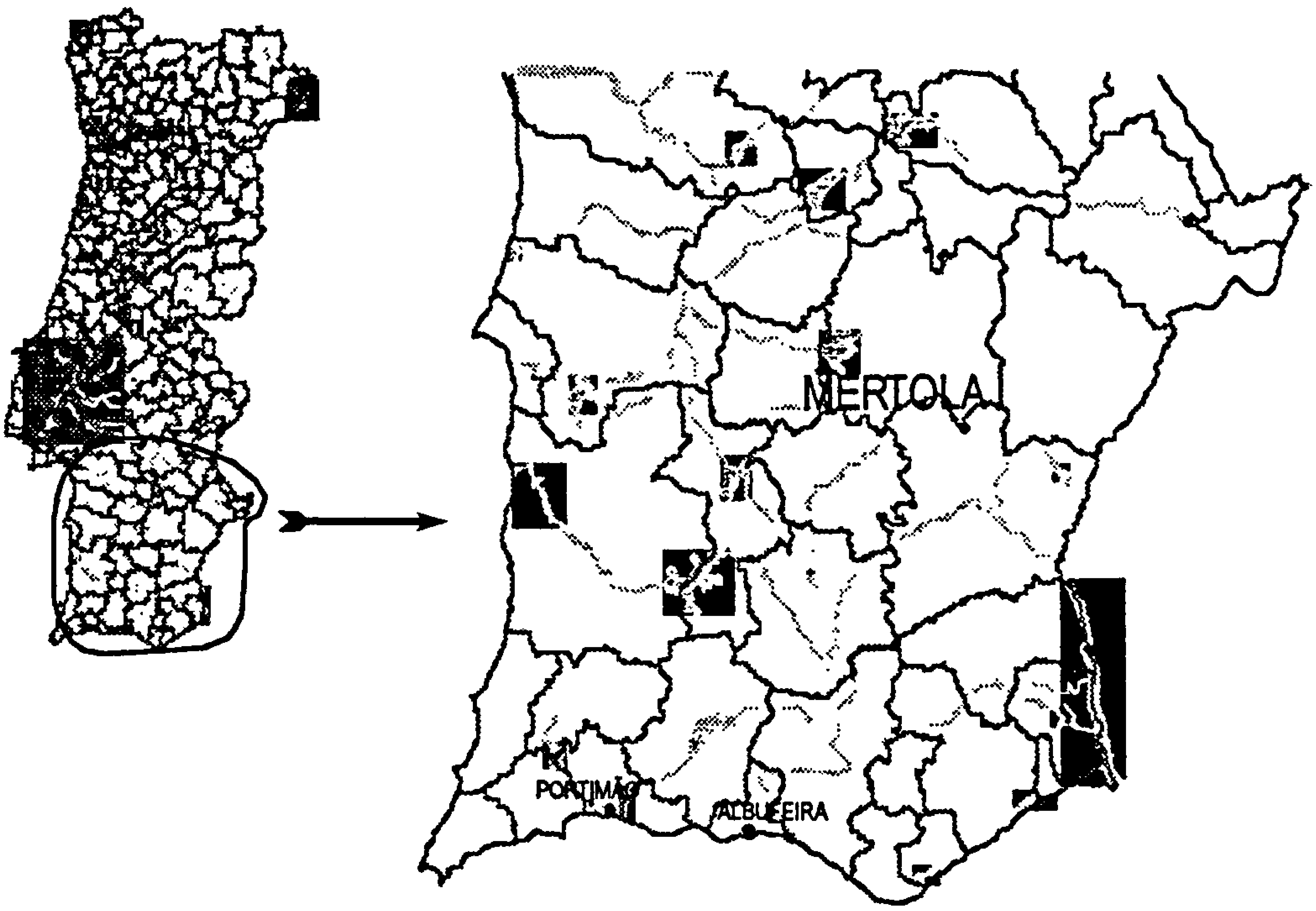
Source: Tchobanoglous, Theisen and Vigil 1993:6

Figure 2.4 indicates that one of the best ways to reduce the amount of solid wastes is to limit the consumption of raw materials and to increase the rate of recovery and reuse of waste materials. The best way to reduce solid waste, from a sustainable point of view, is to minimise the production of waste, adopting new attitudes and behaviours as well as selecting appropriate technologies.

The characteristics of the waste produced are a manifestation of the society in which they were produced. Archaeologists, ethnologists and anthropologists, have been excavating, studying and investigating mankind's history, by studying the different layers of wastes (AGTHM 1977). This is a common situation around the world, and in Portugal there are specific examples of this evidence.

There is an up to date and real case study in Portugal. In Alentejo, a multidisciplinary team (Torres 1983), has been excavating around the historic city of Mértola. The team found layers of different kinds of wastes which were created over the centuries. The information gathered from the excavations has been important in piecing together the social history of Mértola from the Visigoths period, 415 years B.C. The city was a shown to have been a big trading centre from that time until the Moorish era. The Guadiana River, on which Mértola stands, was the key to that trading role. Figure 2.5. shows the physical geography.

Figure 2.5 - Map of Portugal highlighting the Southern regions



Source: Anon 1997.

Certainly in earlier times, the disposal of human and other wastes did not pose a significant problem. The population was small and the amount of land for the accumulation of waste was large. Even so, many historical civilisations gave emphasis to careful waste disposal with naturally sustainable practices such as fertilising the soils with manure (Tchobanoglous, Theisen and Vigil 1993).

Probably the problems with waste disposal began when humans first joined together in tribes, then in villages and communities, and later on in medieval towns. As Tchobanoglous, Theisen and Vigil (1993:5) tell us "littering of food and other solid wastes in medieval towns – the practice of throwing wastes into the unpaved streets, roadways and vacant land – led to the breeding of rats, with their attendant fleas carrying bubonic plague, the Black Death, that killed half of the fourteenth century Europeans and caused many subsequent epidemics with high death tolls".

Early humans did not have a solid waste management strategy per se, simply because the hunter-gatherer existence did not require one. The human groups never stayed in one place long enough to accumulate significant amounts of solid waste. As scarce resources were depleted the group would move on allowing the land to recover without causing concern for other action. However, as humans began to settle in permanent communities with higher concentrations of waste producing individuals and activities, the need for waste management became evident (Ruiz 1993:1.1).

The advent of the Industrial Revolution and the development of a technological society, increased production and the waste disposal problems in Europe, and throughout the industrialised world. In England, the Urban Sanitary Act of 1888 prohibited the throwing of solid wastes into ditches rivers and waters (Tchobanoglous, Theisen and Vigil 1993:5). The Act was passed stop the practices which the new public health management, technology and infrastructure had been developed to overcome. It demonstrates the need for a combination of social and technical responses to waste management issues (Tchobanoglous, Theisen and Vigil 1993).

In Portugal, King John the Third, in 1496, determined that the wards should have men, paid by the residents, to clean the city of Lisbon. However, it was not until 1607 that this kind of service was the subject of legislation and paid for by a tax linked to meat sales in the markets. In spite of this royal legislation, the capital remained dirty and the Tagus River became a dumping site for waste (CML 1995:4). Only in 1907 were a waste management system created for the city of Lisbon. This was followed by the city of Porto in 1925, the "Portuguese northern capital" (CML 1995:4).

In the 1960s, the Beirolas Composting Plant in Lisbon was constructed to solve part of the capital's waste difficulties. However, the plant never performed satisfactorily. It was not matched to the city's wastes characteristics. Heavy equipment raised the operation and maintenance costs and workers lacked correct training. These problems together with the absence of a selective collection of waste in Lisbon were the cause of the under performance. With the political revolution in 1974, the problems increased and the plant stopped working at the end of the decade. It was demolished in 1997 as a result of these operation and maintenance problems. Since then, problems concerning waste treatment and final disposal of waste have continued to increase in Lisbon.

In 1977, Lisbon Local Council invited a private consultant firm to carry out a diagnosis of the city waste management problems and make recommendations. The report opened the way to an intervention by the invited consultant who presented an Action Plan named "Lisboa cidade limpa", which means "Lisbon a clean city" (CESL 1977). As part of this plan the municipality sought to involve all those dealing with city waste management by providing a range of information. One of the publications was the first "Solid Waste Technical Guide" which explains the objectives of the Action Plan and the role of every actor in the new process (CML 1978).

In spite of this effort, both the capital and the rest of the country has encountered grave difficulties in making progress. The waste management systems remain weak, not only in the treatment and final disposal solutions, but also in their collection and transportation. Only in the last two decades, has the country made significant efforts in this area, mainly through the collection and transportation of wastes. Significant efforts to increase the treatment and final disposal levels have been undertaken in recent years with the support of EU funds.

Solid waste treatment and final disposal have been some of the principal challenges which have faced Portugal. Action in these areas, and the Industrial and Clinical wastes field, have received the support of the European Union. The Strategy Plans, the challenges and the efforts within Portugal have been undertaken with significant management and guidance from the Public Administration and Local Authorities. Also private and public entities in the Municipal Solid Waste, have been making a good contribution in order to achieve national targets and goals. The Portuguese authorities are aware that the community's participation is also fundamental, providing information, environmental education, training and monitoring, but at the same time it is also a priority to resolve social and economic problems (MA/INR 1997).

The European Union Strategy for the waste management, supported by the adoption of the framework Directive[4] on waste, were in fact the main bodies responsible for the global backgrounds in Waste Management Plans. The Director General DGXI of the European Union in the Expert Seminar on Waste Management Policy held in Brussels on January 10th/11th highlighted these considerations (Brinkhorst 1994:1). The conclusions reached at the seminar paid full regard to the principle of subsidiarity[5]. All proposals made can be implemented without infringing this principle. The seventeen conclusions are presented in Appendix B.

The focus of this research is the construction and demolition waste stream. This waste stream is influenced by a wide range of diverse factors and activities. These factors which militate against a global approach. They include culture and practice, technological development as well as economic activity. Local environment and geography are also factors that must be considered. They will present difficulties which will need to be overcome for the successful implementation of a strategy. The strategy will need to be developed in accordance with the report of the project group (Morgan and Argus 1995: Part 2:4).

Construction product manufacturers and suppliers, designers, builders and contractors, together with the construction education and training sector have a key role to play in the strategy. This is particularly true with regard to waste prevention and minimisation. The project group have also considered that the European Community has a direct role to play in this context in order to achieve the objectives. They propose:

- Providing a harmonised framework for the implementation of the Strategy.

- Providing mandates to, and liasing with, other agencies and organisations.

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[4] Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC, on waste, is the framework directive for European waste legislation. It contains the terminology and definitions for waste management in the European Union (Morgan and Argus 1995 Part 2: 7).

[5] Principle of subsidiarity has been given a place of prominence and general application in the treaty of Mastrich on European Union. Article A refers to the process of creating an ever closer union among the peoples of Europe (EC 1992b).

- Promoting the dissemination of information.

In summary the key to the development and successful implementation of strategy is an absolute necessity to involve and take account of the characteristics of all the actors in the waste stream.

SECTION 4: INTEGRATED AND SUSTAINABLE WASTE MANAGEMENT

Modern technologies tend to be cleaner technologies. However, they create a constantly changing set of parameters for the designer of solid waste facilities. Every technique must be used to respond to the rapidly changing technologies to ensure that flexibility and utility is designed into the facilities (Roustan et al. 1996:174). But this is not enough. It is necessary to introduce a different attitude. The technological society must re-evaluate itself with a view to becoming to a sustainable society. A society that advocates the 'sound practices' identified by UNEP/IETEC (1996a). "Sound practices" are defined as practices, which are technically and politically feasible, cost-effective, sustainable, and social sensitive solution to solid waste problems (UNEP/IETEC 1996a

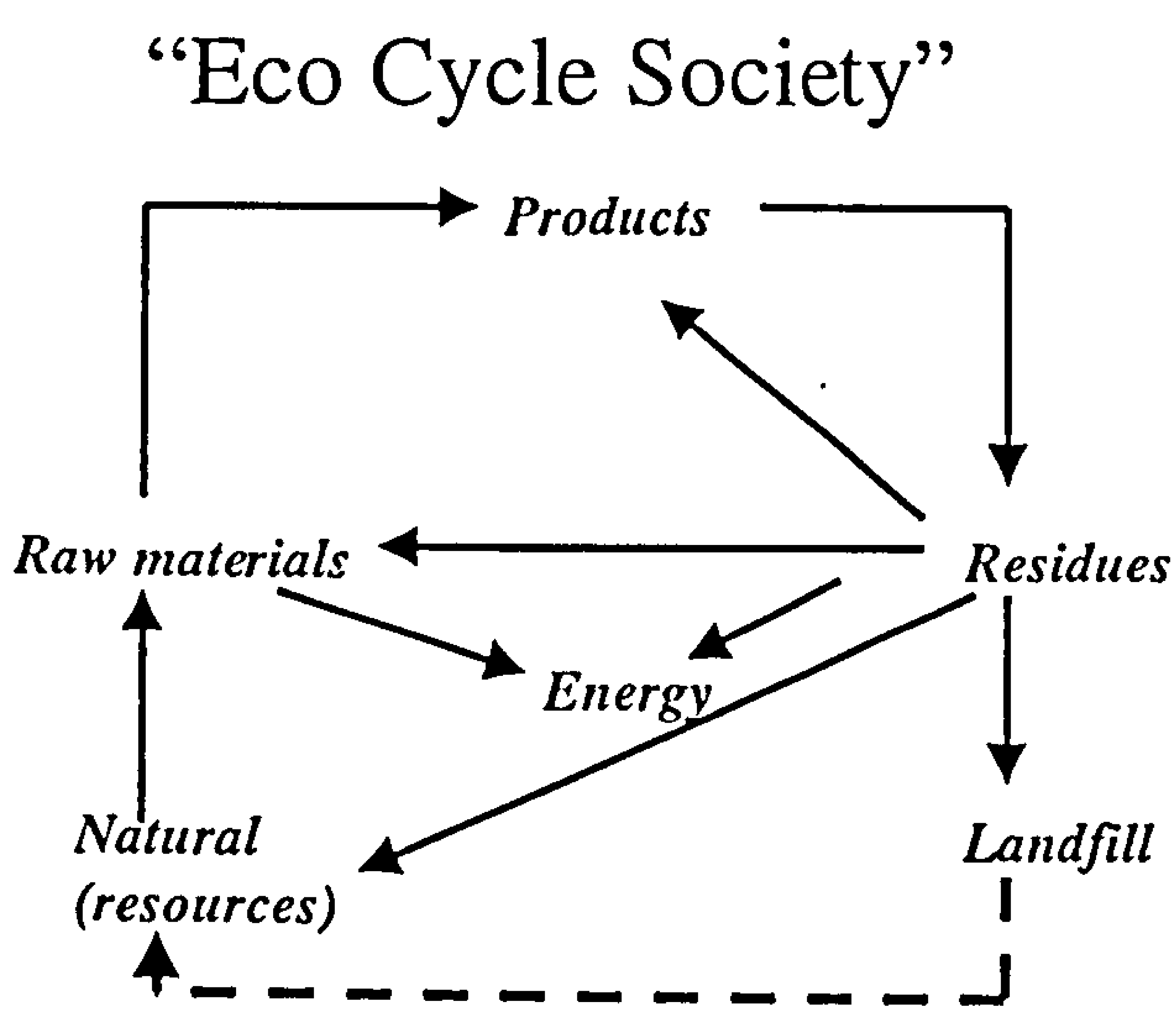
Eco-cycle Society Model

[5] Principle of subsidiariry has been given a place of prominence and general application in the treaty of Mastrich on European Union. Article A refers to the process of creating na ever closer union among the peoples of Europe (EC 1992b).

The Eco-cycle Society model (Hakan 1997) has been posited as a model society, which is more environmentally friendly than the current approach. To move towards such a society requires a number of significant cultural changes (Figure 2.6). Central to the Eco-cycle Society concept are a number of different issues which are moved to the core of the way human society is organised. These actions are the reuse, recycling and energy recovery from obsolete products and the biological re-circulation of organic products. There are other actions, which are presented in Figure 2.6 which, although currently adopted, must be improved. The awareness and knowledge of these principles must drive all attitudes. A critical attitude, highlighted in this model, leads to minimisation of waste production.

The OECD Pollution, Prevention and Control Group (OECD 1998a) studied this situation in the context of the profiles of the OECD member countries. They came to a similar conclusion that there is a need to increase waste minimisation in our societies. In seeking fundamental changes, these principles must become a world objective. Action on all policies and directives, considered key to waste management and other issues must be conceived in the context of those principles. Integrated and sustainable waste management may be defined as a discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of wastes. This must flow in accordance with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations. It must also take public attitudes into consideration (Dias et al. 1993:267).

Figure 2.6 – Eco Cycle Society Concept



Source: Hakan 1997:2.

Integrated Waste Management Systems

There has been long discussion about the use of the term "integrated". Diaz et al. (1993:268) highlighted the widespread use of the term integrated in solid waste management nomenclature. They argued that the term "integrated management" should be reserved for systems, schemes, operations, or elements in which the constituent units can be designed or arranged in such a way that one meshes with another, to achieve a common overall objective.

All functional elements of the waste management system need to be evaluated for use. All of the interfaces and connections between elements need to match the concepts of sustainable principles. When that has been achieved, the community has developed an effective, economic and integrated waste system (Diaz et al. 1993:268).

According to Qasim and Chiang (1994), a successful solid waste management system utilises many functional elements associated with generation, on-site storage, collection, transfer, transport, characterisation and processing, resource recovery and final disposal. All these elements are interrelated and must be studied and evaluated carefully before any solid waste management system can be adopted. Read, Philips and Murphy (1997) when referring to the UK National Strategy for Waste Management, "Making Waste Work", placed special emphasis on the hierarchy of waste management options (see Figure 2.7).

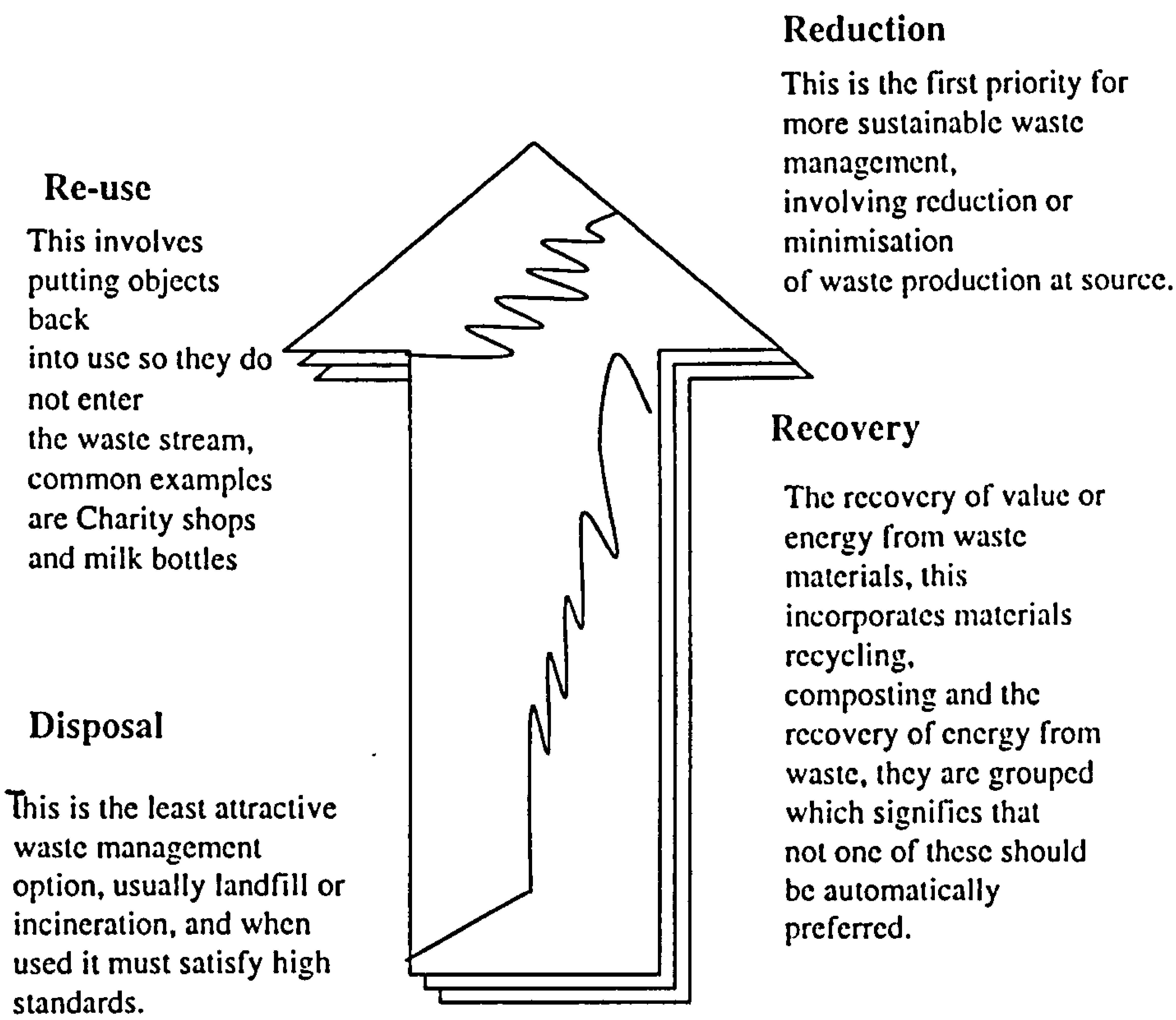
Pets and Edulgee (1994:20) pointed out that a real framework for waste management, must emphasise the three elements:

- The formulation of policy.

- The regulatory and control regime.

- The availability of appropriate treatment and disposal techniques and facilities in order to implement the selected waste management route for a particular waste stream.

Figure 2.7 – The UK Government current waste policy is based on a hierarchy of waste management options



Source: Read, Philips and Murphy 1997.

The selected waste management route is determined after considering the following hierarchy of options, which is stated in the European Union Solid Waste Strategy (EC 1996c):

- Waste reduction at source, waste minimisation in a prevention attitude.

- Waste reuse and recycling.

- Recovery of raw materials and / or of energy.

- Treatment of wastes.

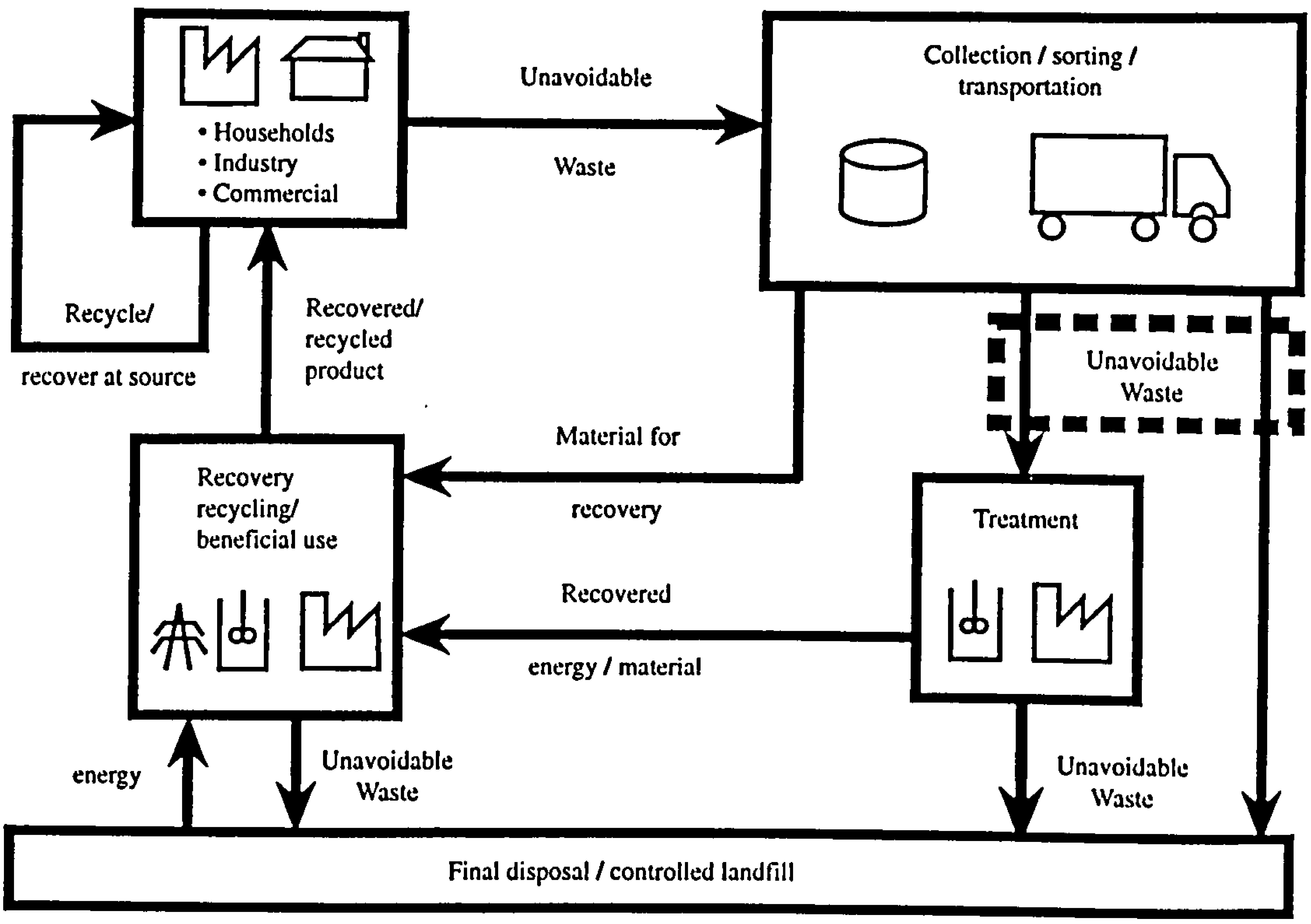
- Disposal of the residues from treatment, and of other unavoidable waste.

A generalised waste management cycle can be depicted, as Figure 2.8, indicating the interaction between the various options. The cycle commences with the generation of waste by industry, households, commercial premises, and others. Following the above hierarchy, the first priority is for these generators to reduce waste generation at source, and to implement appropriate segregation and recycling policies.

Figure 2.8, presents a sequence of actions that can be shortened by circumventing the treatment stage to final disposal of waste.

Figure 2.8 – The waste management cycle

Waste Treatment and Disposal

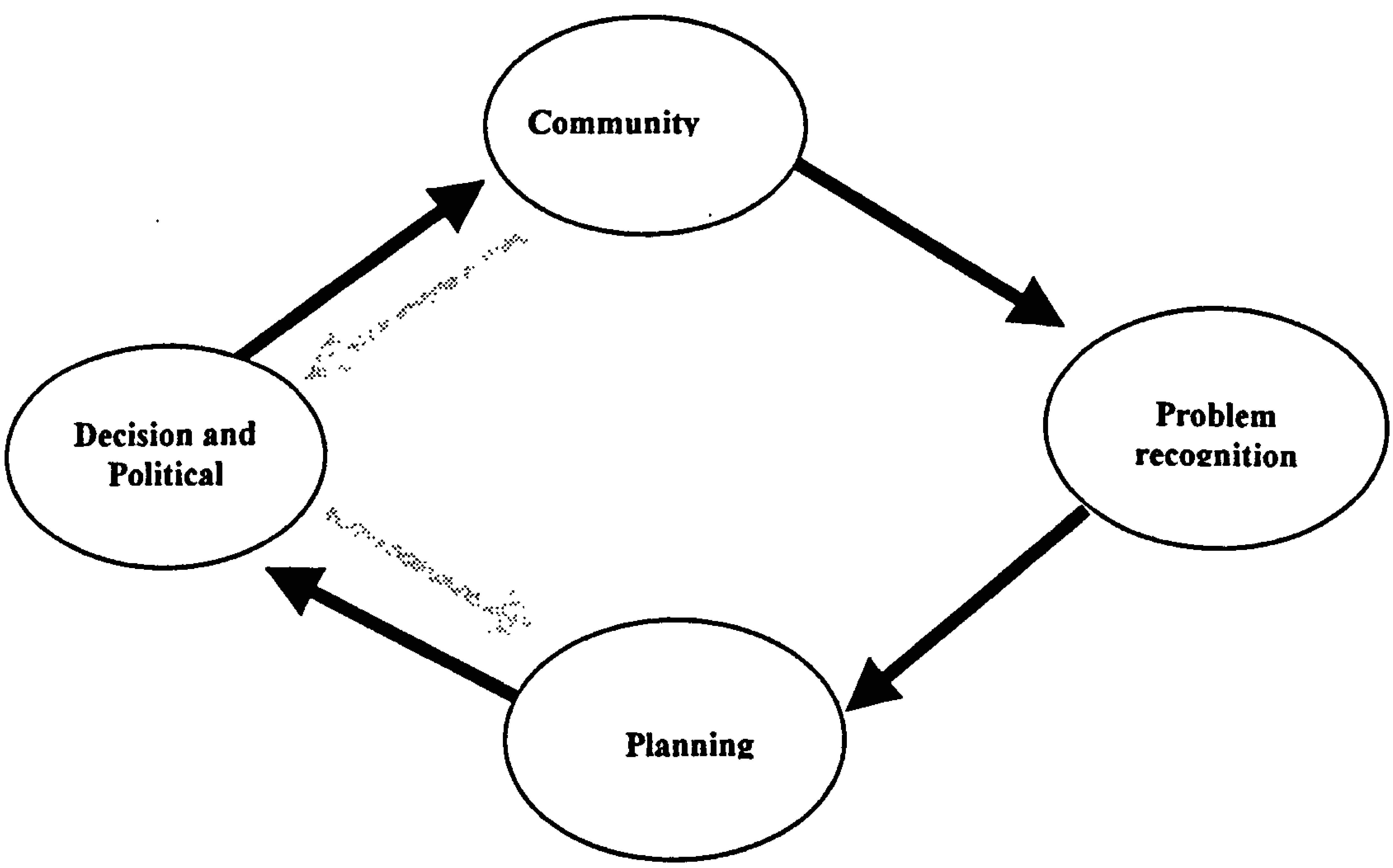


Source: Pets and Edulgee 1994:21.

The Community Participation

As was pointed out by Tchobanoglous, Theisen and Vigil (1993:15), integrated solid waste management, encompasses a wide range of individual activities, which must be combined in such a way that the public, politicians, decision makers and planners are able to recognise and understand the important relationship in the planning process. The planning activity commences once a community's need has been articulated and the problem has been recognised. Problem recognition is important because for results to be meaningful they must be related to some community need (see Figure 2.9).

Figure 2.9 – Community Problem Solving Cycle



Source: Tchobanoglous, Theisen and Vigil 1993:875.

The consideration of all these situations leads to a dynamic problem solving cycle defined as presented in Figure 2.9 where gray arrows indicate feedback. Community needs are usually identified in response to issues related to costs and service being provided, resource utilisation and environmental protection. The extent of the need is often determined by the social standards of residents, institutions and businesses. The problem of recognition and definition will be in the cycle. The responsible decision-maker perceives and interprets community needs. They are also responsible for problem definition and specification, by planning and defining the activity undertaken by agency staff or consultant, as directed by decision-makers.

Alternative programs are developed to solve specific problems. Decisions and political activity will be the action step in the problem solving cycle. The act of decision-making is to review alternatives, select alternatives to be implemented, and make financial, operational and political decisions. There are key elements to include in order moving towards a framework for integrated management, according UNEP/ITEC (1996a). They are:

- Setting policies.

- Planning and evaluating solid waste activities by system designers, users, and other stakeholders.

- Using waste characterisation studies to adjust systems to the types of waste generated.

- Physically handling waste recoverable materials, including separation, collection, composting, incineration, and landfilling.

- Marketing recovered materials to brokers or to end-users for industrial, commercial, or small-scale manufacturing purposes.

- Establishing training programs for solid waste workers.

- Carrying out public information and education programs.

- Identifying financial mechanisms and cost-recovery systems.

- Establishing prices for services, and creating incentives.

- Managing public sector administrative and operations units.

- Incorporating private sector business, including informal sectors collectors, processors, and entrepreneurs.

Waste Management in European Union Context

Portugal's entry into the European Community in 1987 brought a breath of fresh air to the country and opened the door to more significant development (Nunes 1994:63). National resources have been added to by European funds and grants for development and modernisation. Portugal has taken advantage of funds to aim at equalising the differences in waste management indicators within European Community itself. Table 1.1 adapted from (Eurostat 1997) illustrates Portugal's position in terms of per capita waste production, and other significant indicators.

Table 2.1 – Waste production in Europe

Countries	Population Milion 1995	% of Total Population which is urban	MSW Production Ton	Industrial Waste Producion Ton	Agricultural Waste Ton	Minning Production Ton	C&D Production Ton
Belgium	10,0	----	3 470	26 700	53 000	7 069	690
Denmark	5,2	85,5	2 400	2 400	----	----	1 500
France	57,8	72,8	17 000	50 000	400 000	100 000	----
Finland	5,1	60,3					
Italy	57,9	70,5	17 300	39 978	29 830	57 000	34 474
Ireland	3,5	58,4					
Luxemburg	0,4	----	170	1 380	----	----	4 000
Germany	81,3	86,5	19 483	61 424	----	9 468	118 826
Norway	44,4	77,0					
Spain	39,3	80,7	12 546	5 108	45 000	180 000	----
Greece	10,3	65,0	3 147	4 304	90	3 900	----
United Kingdom	58,1	89,5	20 000	50 000	250 000	230 000	25 000
USA	263,1	76,2	208 760	760 000	150 566	1 400 000	31 500
Portugal	9,9	36,4	2 350	662	202	3 900	----
Japan	125,9	77,9	48 283	312 271	62 900	26 017	57 886

Source: Author adaptation from (Eurostat 1996) and (Seager 1995)[2].

Over the past three decades, the European Community has adopted a broad spectrum of legislation aimed at restoring and protecting the environment (EC 1992a). This information was collected together, in several volumes, in 1992. The European Union Commissioner in his preface says that this information about Community environmental legislation will provide a basis for the common endeavour of meeting the environmental changes in the coming century. Volume 6, which is a compilation of legislation on waste area, gives global information about all the legislation and Regulations concerning this matter (EC 1992a).

Directive 91/156/CEE from 18th of March, defines waste as any substance or object (in the categories set out in Annex I) which the holder discards or intends or is required to discard.

[2] The figures from Eurostat are related from 1986 to 1990, depends on the information provided by individual countries. The Table has been completed in relation to the 1995 population and a percentage of the population living in urban areas based on information from the State of the Environment Atlas (Seager 1995).

The first Directive providing the framework whereby the Member States could control the disposal of wastes nationally, instead of locally was Directive 75/442/EEC – Waste Framework (EC 1975). This was substantially revised and amended in 1991 by the Directive 91/1567EEC (EC 1991). The objective of the 1991 Directive was to stress the idea that Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with the 1975 Directive. It also stresses the necessity of Member States informing the Commission about their measures. The 1st April 1993 was the guide date for application of the 1991 Directive. The Directive also provides a legal framework for the avoidance, management and disposal of wastes as set out in the Commission's Waste Management Strategy.

This Waste Management Strategy document is the first of sector policy documents to be issued by the European Union. These legislative proposals and activities are organised according to five strategic guidelines. They are:

- prevention of wastes by technologies and products.

- recycling and reuse.

- optimisation of final disposal.

- regulation of transport.

- remedial action.

The application of the 1991 Directive, as well as all other legislation has not been easy. Environmental decisions and regulations are always very closely linked to social and economic problems and with each country's culture. This is also well expressed in the Fifth European Union Programme of Environment and Development "Towards Sustainability". The document states that there is growing world-wide concern at the continuing deterioration of the state of the environment and the serious degradation of global life-support systems. A crucial element of the Community's strategy for the 1990's, developed in more detail in this document, is to promote policies and programmes that will improve the quality of human life world-wide through a more equitable distribution of natural resources. The drive to raise living standards, alleviate poverty, increase life expectancy and improve food security places a considerable burden on the word's natural resource base. (EC 1992b: 26).

The Recent Trends

At European Union level recent developments concerning the waste stream directly related to this thesis. They include the decision to revitalise the working group which was responsible for the 1995 construction and demolition European Union report (Morgan and Argus 1995). This report of the Project Group to the European Commission "Construction and demolition Project in the Framework of the Priority Waste Streams Programme of the European Commission" was presented in October of 1995. A range of participants were involved in its preparation including European Union staff, Building Industry, Material producers, Architects, Consumers, Recycling and Recovery, Waste Management, Environment protection associations and Member States representants (Morgan and Argus 1995: Part1:4). This important work was divided in three parts as follows:

> ". Part 1 – Information Document. This document introduces and provides the background to the construction and demolition waste priority waste stream project and summarises the existing data on construction and demolition waste arisings. It summarises the legislative, regulatory and management systems presently in place in the Member States and set out the process by which

the strategy for the management of construction and demolition wastes has been developed.

. Part 2 – Strategy Document. The document identifies the key issues and the roles of the participants in construction and demolition waste management and set out the definitions adopted by the project group. It sets out the discussions and summarises the findings of the project group and identifies the actions required to improve construction and demolition waste management and proposes a strategy to achieve improvements in construction and demolition waste management.

. Part 3 – The recommendations have been derived from, and follow on from, the information and strategy documents, and sets out the specific recommendations of the project group (Morgan and Argus 1995:Part 2:4)"

Only in 1998 did the European Union restart work in this priority waste stream. They asked the same consultant group and member states to disseminate information on the state of the art. Other priority waste streams, within the European Waste Strategy have been given greater priority in the preparation of specific future Directives. These other areas are the situation for the end of life vehicles, piles and batteries and electronic and electric material, as well as the package waste stream. This last area has a specific Directive and a particular importance in the integrated waste management policy.

The information received from the European Union was that developing a strategy for the construction and demolition waste stream was particularly difficult. For instance the qualities and quantities of waste in the construction and demolition waste stream are different in the Northern countries compared with the Southern European countries. The EU took the view that this area should be studied at national state level and the solutions developed at that level. Now the situation is completely different and there is a return to the guidance and support outlined in 1995. The EU started by contacting the country focal points members of the 1995 working group as well as all the other significant actors in this area. In Portugal information was received that focused on the expertise of member states more advanced in goals and targets in this waste stream such as Denmark, Holland, Germany, Belgium, United Kingdom and France. The results of this work led to another report produced for the Directorate General XI of EU. This directorate has the responsibility for the waste management field, waste management practices and their economic impacts (Symonds et al.1998).

The building and construction industry is responsible for impacts, which are difficult to minimise without a global and integrated approach. How it is possible to lessen the quarries opening, and the sand extraction from rivers and coastal areas? These issues and the deconstruction process have to be incorporated into the thinking at the design stage of construction projects. There is a need to develop reuse and recycling solutions and preventative attitudes. How is it possible to minimise raw materials extraction without all the actors' in a chain aware of these environmental friendly attitudes? The role of public administration in creating environmental and also economic and social conditions to improve the practice and policy is critical and must be a priority.

The need for specifications for the application of recycled materials as aggregates to different uses is also fundamental. Developing second hand markets, increasing the taxes on the extraction of raw materials, increasing the landfilling levy will make a major contribution to these goals. The contribution from the sector associations, creating conditions to the appropriate work of the contractors in this area is also critical. The process will be enhanced by the introduction of the polluter pays principle and also by creating financial incentives for every company which adopts environmental attitudes. The ISO 9000 and 14000 norms and their application concerning environmental safety and quality accreditation could be significant additional tools to reach these objectives.

ISO 14001 (environmental management systems) and ISO 14031 (environmental management) should promote the aim of waste minimisation (Woods 1998). This will be developed in Chapter 4, Section 4.1. In Portugal (Sequeira 1995) various studies have illuminated the role of environmental management systems under the guidance of the working group from ISO/TC 207 and their sub committees.

In UK, for example, there have been some studies and publications concerning the construction and demolition waste stream but in Portugal the problem definition is still in its infancy. Studies developed by the management policy, with a document named Waste Management Planning, Principles and Practice, which is a guide on best practice for waste regulators (DoE 1996a). A Code of Practice in waste management, has been produced (Department of the Environment, Scottish Office, Welsh Office 1991), as well as some technical and scientific work developed at the Public Research Institute, the Department of the Environment (DoE 1995[a]) and (DoE 1995b) also include waste Building Research Establishment (BRE). Some studies, for example the Construction Industry Research and Information Association (CIRIA 1995a) report on practical applications within the field of discussion.

Important work has been developed in this area in Europe and also in other countries outside Europe. Chapter 4 will address this issue. In Portugal some work has been developed with the INR participation, with the scientific support from the University of Salford, and technical advice from the European Union. Portugal is at the beginning of an appropriate approach to the construction and demolition waste stream within the context of the concepts of sustainable construction.

Chapter 8 will discuss some technical work of investigation and utilisation of natural material from road excavations on base and sub base of roads. The seminars and meetings in Portugal on these construction and demolition waste stream issues were organised by the Portuguese Waste Institute (INR). They were organised with scientific support from the University of Salford (UK), the Institute of Wastes Management (UK) and with contribution of the Symonds Travers Morgan consultants (Symonds et al. 1999). Symonds Travers Morgan act as consultants to the European Union in this special waste stream. Three of the seminars were held on behalf of the Portuguese Waste Institute, and another at the Ministry of the Equipment, Planning and Territory

Administration. A further seminar was also developed with the support of the Sustainable Development Institute from the Orada Foundation at Monsaraz, Alentejo Region. An in depth discussion of the proceedings of these workshops and seminars will occur in a later Chapter. In all of these events the University of Salford (UK) made a valuable contribution and there was some input from the Institute of Wastes Management (UK). The British Council in Portugal as well as the Portuguese Waste Institute (INR) have given significant support to the events. They were the first significant events dealing with these issues and providing channels of information and reports of actions in Portugal.

Some work in the application of soil recycling in road works has been done by the Portuguese National Civil Engineering Laboratory (LNEC). These will also be discussed in Chapter 8. The chapter will also explained and describe the Portuguese experience and knowledge in this area.

Summary

This Chapter addresses the sustainability concept and its role in guidance towards a new future with a different but close relationship between environment and economic development. Sustainability has been defined as has sustainable development. The differences between the concepts have been discussed and analysed. They are not synonymous. Key principles of sustainability, the social and psychosocial approach, which is directly linked with policies, are considered fundamental to achieve better environmental performances and results. Capacity building, to improve sustainability and the limits to growth within the sustainable development concept are also discussed.

Sustainable development indicators are discussed and defined within the context of contributing to a European framework for sustainable development. Priorities of waste management, within the context of the sustainable development concept are discussed. They follow the hierarchy of prevention, reuse, recycling, recovery, treatment and finally disposal. Sustainable and integrated management is presented in a form illustrating the interactivity of several sub systems in waste area. They match the hierarchy of the sustainable management from waste production, collection recycling, transportation to treatment and final disposal.

A new eco-cycle society model was presented demonstrating na approach towards sustainable practices and a new future where environment and nature will be appreciated at a different level. The importance and role of community and the strength of community participation are also discussed, highlighting the importance of the social and psychological environmental perspective. Finally, waste management in the European Union context and recent trends towards better environmental management are also discussed.

CHAPTER 3:

TOWARDS SUSTAINABLE CONSTRUCTION

"... Our villages and towns were built from what came closest to hand: stone in Northamptonshire, timber in Herefordshire, cob in Down, flint in the Sussex downs, brick in Nottinghamshire. Each town and each village has a different hue, a different feel, and foster a fierce loyalty in those who belongs there."

(HRH CHARLES, PRINCE OF WALES, 1989)

INTRODUCTION

This Chapter focuses on the Construction Industry. It discusses the main characteristics and relative industrial position of the industry in Portugal. It explores its interaction with the environment. The changes leading towards sustainable construction together with the guidelines of a new strategy to achieve this new concept are discussed. The Chapter has five sections. The first section defines the construction industry and the main characteristics in a world and European context. Section two is focused on the Portuguese construction industry. Section three deals with the relationship between the construction industry and the environment. Section four is focuses on changes in culture and attitudes necessary to achieve sustainable construction. Section five discusses the implementation of a new strategy to achieve sustainable practices.

SECTION 1: CONSTRUCTION INDUSTRY SECTOR AND ITS MAIN CHARACTERISTICS

The world-wide overview

The Construction Industry is a key part of the economic sector. However it should be moving towards sustainable practices without losing its role and interaction in the global economic sector. Meanwhile construction Industry activity is directly linked with a country's economy. There is also a wider difference between countries, from developed economies through to transition economies and developing economies.

Developed economies are characterised by slow growth but without recession. Social problems in these economies are related to growth in human numbers, to a voracious use of natural resources, and to economic decisions focussed on short-term gains that do not take head of social and environmental impacts (Bormann and Kellert 1991).

Transition economies are characterised by major difficulties. They are a function of their specific characteristics. They tend to have higher unemployment levels, significant social and environmental problems and normally, very high inflation rates.

In developing countries, located in South and East America and in Africa, the growth in per capita GDP has been small. They experience unemployment, poverty, health problems and a limited carrying capacity within which to improve the sustainable standard of life of their citizens. They also have large external financial deficits. Table 3.1 gives information about world output from 1981 to 1997 (Euroconstruct 1997:12).

Table 3.1 – Growth of world output, 1981 to 1996

Annual percentage change								
	1981-90	1991	1992	1993	1994	1995	1996[a]	1997[b]
World	2,8	0,8	1,8	1,3	3,0	2,4	3,0	3,0
Developed economies	2,9	0,8	1,6	0,7	2,6	1,9	2,4	2,5
Economies in transition	1,7	-9,2	-13,6	-9,1	-4,4	-1,4	-0,9	2,0
Developing economies	2,4	3,3	5,2	5,2	5,5	4,6	5,7	6,0

Source: Euroconstruct 1997:12.

a - Preliminary estimate

b - Forecast

c - Calculated as a weighted average of individual country growth rates of gross domestic products (GDP)

d - Based on reported GDP, which seriously underestimates activity in several countries.

The data from the last UNDP report (PNUD 1998) shows the gap between rich and poor countries increasing. Economy globalisation does not appear to protect or enhance the position of poor countries. The World Bank and the International Monetary Fund at its meeting in October 1998 (Rebelo 1998) have strong concerns about pressures on the environment. They have issued a "red light" warning on these issues. These concerns are especially directed to the seven most developed countries, the G7 countries[1], which have the most developed economies. Within these economies there is a need to change attitudes to resource consumption. There is a need to find economic solutions to problems whilst reducing resource consumption and preserving standards of living. There is a clear need to change lifestyles, and to stop exploitative relationships with poor countries, where poverty and other world living standards indicators are at an unacceptably low level. In October 98 Europe and USA were still considered to have sound economies but in 1997 the Asiatic countries, Russia and Latin America were reported to have economic difficulties (Euroconstruct 1997).

According to the report "European Construction to 2002" (Euroconstruct 1997: 13-14), countries continue to protect their sensitive sectors from foreign competition. The World Trade Organisation is considering the significant value of this protection within the current negotiations and with respect to the trade agreements. Countries with sound economies must enable and support these challenges to protectionism but some times the issues are not simple. They involve ethical positions and concerns for health and cultural and social stability. The report "European Construction to 2002" goes on to state that "All in all, the 1990' have so far been good to the global economy, although major differences in development speed and factual adjustment can be observed. A booming world trade and a spread of free market policies, have helped bring peace and prosperity to a growing portion of the world's population". Nevertheless some doubts have recently been expressed concerning this benign view. The major factors generating favourable development were listed as follows (Euroconstruct 1997:14):

- The need for continuous development towards free trade. The move towards free trade has lost momentum. Some economic and environmental rules have been strengthening by several organisations in order to protect the weakest economies. There is a need for another big round of negotiations to press forward the free trade issues. These might begin around the year 2000.

- The drive to cut budget deficits in industrial countries. Support for deficit reduction has ebbed mainly in Europe but also in the United States. However in

[1] Group G7 is made up of the following countries United States of America, Canada, Japan, Germany, United Kingdom, France and Holland.

Japan the deficit is again increasing. This represents a big concern in the global context of the industrialised economies.

- Widespread deregulation. Although a number of deregulationary measures have been decided upon the implementation in the political and administrative processes is still lagging behind in a number of countries. This situation is enhanced by the difficult economic situation, with increasing demand for state-subsidies and market protection, to uphold existing economic structures.

- Growing harmony between former cold-war adversaries in Europe. An increasingly nationalistic Russia and problems in some former USSR countries threaten post cold-war harmony in Europe. This is due to ethnic and political difficulties resurfacing, not only in the Balkans, but also in China and ex-soviet Asian states.

- An increasing co-operation among the emerging economic powers in Asia. Increasing world problems and the instability and fragility of their economies has prejudiced this increase in co-operation. Political problems in African countries could also contribute to this situation.

This is a limited view, based on the multilateral trading system and other assumptions within the World Trade Organisation guidelines and objectives. The founding of the World Trade Organisation as a result of the Uruguay–round Conference, can be described as an extraordinary event. The World Trade Organisation member nations agreed on approximately 30.000 pages of text. The text covered international trade and trade liberalisation in areas before only encompassed by multilateral systems. The areas covered included services, intellectual property and investment. With 125 member countries and 28 candidates for membership, this Organisation is powerful with increasing influence over growth and development in the world. There is a weakness in its position with respect to the concepts of sustainability. There is a need to improve its approach to sustainable indicators and policies. There is a need to find another world model. In that model the sustainability indicators would have greater weight, together with the combating of hunger and poverty, in the setting of priorities and objectives. The economic objectives must be measured against cultural, social and environmental objectives as set down in the Agenda 21 programme of Action for Sustainable Development (UN 1992a: 19).

The world economy has known, several different and distinct phases in the last decades. The first, was a strong growth and development, in terms of production, in the early 80's. The second phase at the end of the same decade showed growth slowing to below 2 %.

According to the Organisation for Economic Co-operation and Development (OECD 1997b), the world economy has been growing and has maintained a substantial growth and development during 1997. This was particularly true of the US economy. This expansion was coupled with a low inflation rate and low unemployment. In the OECD countries[2] the economy growth is predicted to be around 3 %, in 1998 and 1999. The western economies contributed to this situation, particularly the American economy that has been the driving force of this increasing rate of growth (OECD 1997b). This growth has sometimes been at a significant cost to the environment and to nature. The good performance of these western economies is based in the three following factors (Euroconstruct 1997):

- Reduction in public sector expenditure and controlled inflation, which appears to produce low interest rates and investment returns.

- Financially healthy enterprise sector, which means companies have good results and are not dependent on external financial loans.

- Stable prices for raw material and in particularly the reduction in petroleum prices.

[2] OECD countries: Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, The United Kingdom, The United States of America, Japan, Finland, Australia and New Zealand

These issues and observations have been drawn from an overview of international trade and industry. The construction industry is one of the engines of modern economies and so these issues and observations are specifically applicable to it.

The European scenario

The performance of the construction industry is fairly uniform across the world and European Union is not an exception. Construction industry production in the European Union countries and Norway and Switzerland, (but with the exception of Luxembourg and Greece[3]), increased during 1997 by +0.4% (AECOPS 1998:23). This is an increase from a low point of –0.6% in 1996. Production in 1997 could be entering a new phase, as an accelerated production rate of about 1.7% is forecast for 1998. This is the latest date for which figures are available. The situation is very different in each individual country. Rates of production increase in Germany continue to decline and now stand at +2.3%. French production also is in decline with a negative rate -0.9%. Switzerland at -6.1% and Sweden at -1.9% are the other European countries where production is falling. In contrast, there are countries within the European Union where there was production growth in 1997. These countries included Portugal at +12.5%, Ireland at +12.2%, Finland at +1.4% and Denmark at +4.2% (AECOPS 1998). Table 3.2 illustrates gross construction industry production at constant prices in Europe from 1988 to1998.

[3] No data available concerning Luxembourg and Greece

Table 3.2 - Gross construction industry production at constant prices from 1994 to 1998 in billions of euros.

	1994	1995	1996	1997	1998 (F)
Austria	30,6	31,1	32,0	32,5	33,0
Belgium	23,1	23,5	23,0	23,6	24,3
Denmark	13,8	14,7	15,8	16,5	16,8
Finland	9,2	9,5	9,9	11,2	12,4
France	102,5	102,6	98,7	97,8	99,7
Germany	216,6	217,2	210,5	205,7	205,2
Ireland	5,8	6,6	7,8	8,7	9,5
Italy	92,4	93,4	95,1	95,6	98,5
Holland	32,1	32,7	33,1	34,3	34,6
Noreen	12,9	12,9	14,1	14,4	13,6
Portugal	10,0	10,6	11,1	12,5	13,0
Spain	51,7	54,3	53,8	54,9	56,4
Sweden	21,3	21,0	21,3	20,9	21,6
Switzerland	28,0	27,1	25,6	24,0	23,5
Grate-Britain	68,5	68,1	68,9	71,4	73,6
TOTAL	718,6	725,1	720,7	724,0	735,7

(F) - Forecast
Source: AECOPS (1998).

New residential construction fell in 1996 to (+) 1.6% and contracted in 1997 to (-) 0.3%. The reason for this contraction was due to demographic stagnation in the principal European Countries. Another factor was the reduction in public investment in this area as a result of efforts to restrict public expenditure to achieve the Mastrich[4] Treaty criteria for entry into the Euro, the new currency system (Nunes 1994: 73).

Table 3.3 shows gross construction industry production by country and by type of construction works, at 1996 constant prices. This European situation is directly comparable with trends in the world economy of slowly accelerating growth. Significant threats appear more significant in the Middle East and some countries in Central and South America.

4 The Maastrich treaty covers the economic, monatery and political union. It is clear in the relationship of the two first objectives are too vague to the last one (Nunes 1994:78)

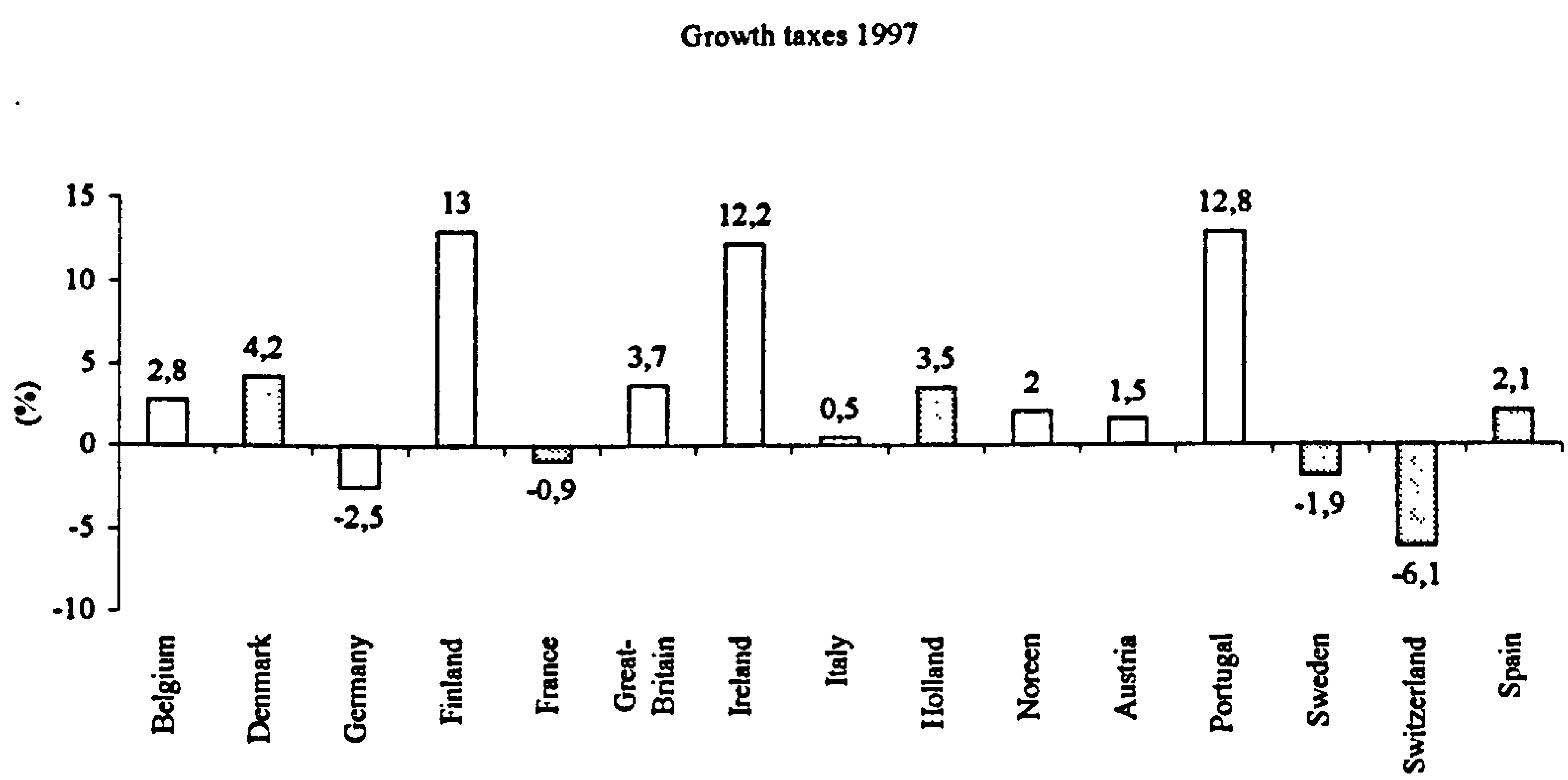
Table 3.3 – Evolution of construction industry production by country and type of civil works in Europe in 1996 in billions of euros.

	Buildings			Build. Subtotal	Civil Engineering	Modern. and repair	Building Total
	Resid.	Not Resid. Privates	Not Resid. Public				
Austria	8,9	5,7	1,9	16,5	5,8	10,2	32,5
Belgium	7,0	5,8	0,9	13,7	3,2	6,7	23,6
Denmark	2,1	2,0	0,8	5,0	4,2	7,2	16,5
Finland	2,2	2,0	0,5	4,7	2,7	3,7	11,0
France	20,6	10,3	4,2	35,1	20,1	42,5	97,8
Germany	72,2	33,9	5,9	112,0	35,8	57,9	205,7
Ireland	2,7	1,6	0,4	4,7	1,7	2,4	8,7
Italy	18,5	12,2	2,6	33,3	18,8	43,5	95,6
Holland	8,1	4,0	1,7	13,8	6,7	13,8	34,3
Noreen	1,8	1,6	1,0	4,5	4,2	5,8	14,4
Portugal	3,8	1,7	1,6	7,1	4,8	0,5	12,5
Spain	17,7	4,8	3,2	25,7	16,5	12,7	54,9
Sweden	1,0	3,6	2,0	6,6	6,8	7,6	21,0
Switzerland	7,2	2,5	1,1	10,7	7,5	5,9	24,0
Grate-Britain	9,4	13,9	4,2	27,5	13,1	30,8	71,4
TOTAL	183,1	105,6	32,1	320,8	152,0	251,1	723,9

Source: AECOPS (1998: 234).

Since 1990, in Europe, there has been slow growth, but without recession. There are concerns about the public deficit and the high degree of inflation control in order to meet the Mastrich treaty goals (Nunes 1994:84). Table 3.4 presents the construction market evolution with growing rate from 1997.

Table 3.4 – The Construction market evolution in Europe with the growth rate of



Source: AECOPS (1998: 24).

Confidence in the financial markets is one factor, which leads to maintenance and growth in construction industry production (ECIF 1998). Gross production in Construction has been increasing both in prices and volume from 1994 to 1998. This is illustrated in tables 3.5 and 3.6 respectively.

Table 3.5 – Gross Construction Industry prices evolution in Europe in billions of euros

	1993	1995	1996	1997	1998 (F)
BUILDINGS					
Residential	182,053	186,706	183,653	183,139	182,492
Non Residential					
Privates	103,058	104,483	105,277	105,608	107,313
Publics	35,828	35,088	33,489	32,079	31,955
CIVIL ENGINEERING	157,961	156,464	151,850	152,015	154,720
Renovation and modernisation	239,884	242,767	246,401	251,100	259,384
TOTAL	718,784	725,508	720,670	723,942	735,863

Source: AECOPS (1998: 235).

Table 3.6 is about the volume production rates from 1994 to 1998.

Table 3.6 – Increase in volume of production rates from 1994 to 1998 (%)

	1995	1996	1997	1998 (F)
BUILDINGS				
Residential	2,6	-1,6	-0,3	-0,4
Non Residential				
Privates	1,4	0,8	0,3	1,6
Publics	-2,1	-4,6	-4,2	-0,4
CIVIL ENGINEERING	-0,9	-2,9	0,1	1,8
Renovation and modernisation	1,2	1,5	1,9	3,3
TOTAL	0,9	-0,6	0,5	1,6

Source: AECOPS (1998: 235).

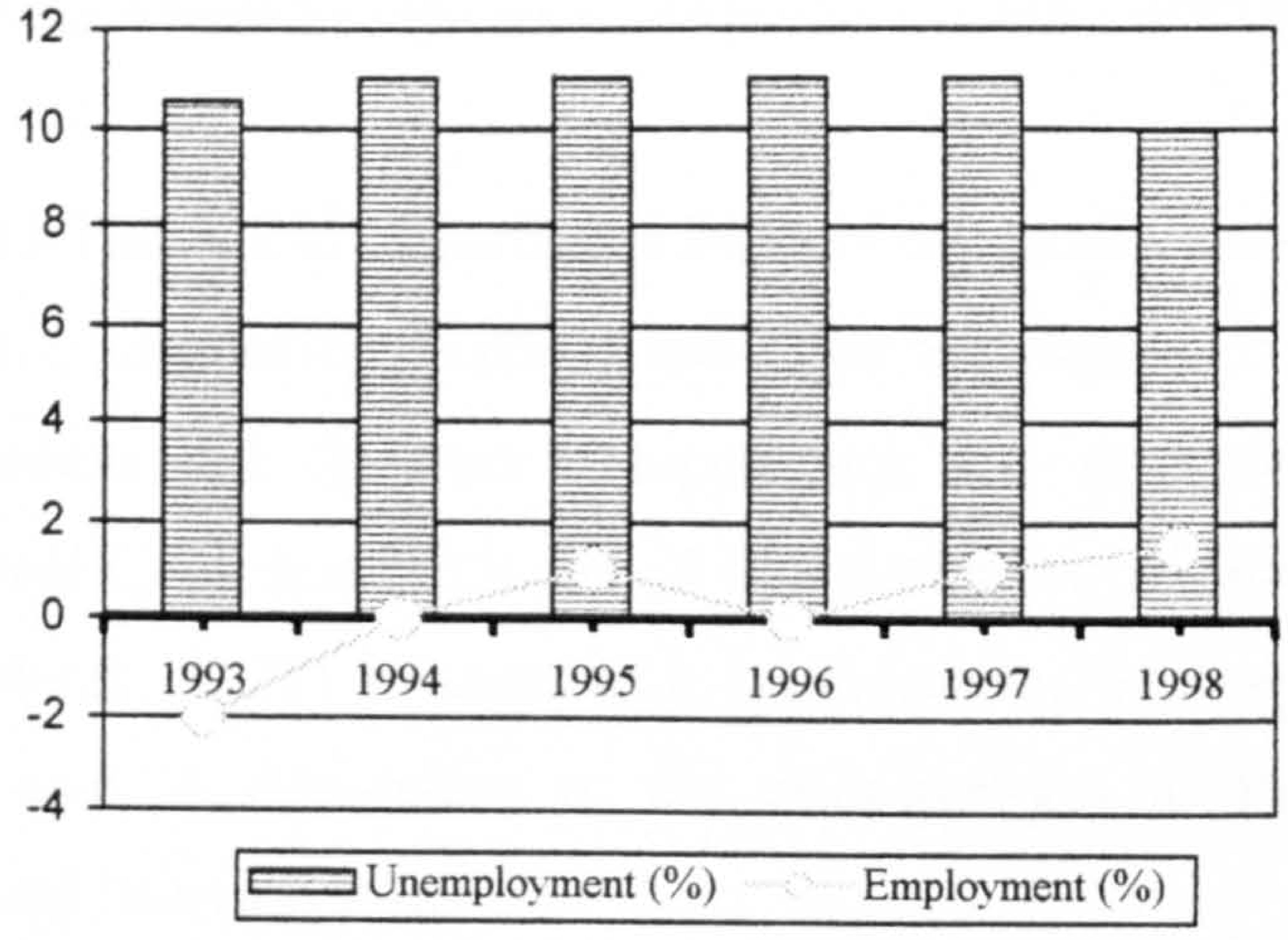
In Europe, the main concerns and efforts have been concerned with the start of the European Monetary Union (EMU) in 1999. This has produced difficulties for most countries in the EU. The observance of the Mastrich treaty goals created political and social conflict. Europeans immersed in a consumer lifestyle found the constraints social conflict. Europeans immersed in a consumer lifestyle found the constraints following from the Mastrich treaty goals stressed the middle social classes (ECIF 1996). There was also conflict in labour relations as a result of wage control. The Mastrich treaty goals also provide guidelines and significant information to countries outside the EU, which seek to join.

According to a recent report (Barreto and Barbosa 1998) from the Portuguese Financial Ministry, the next thirty years will see an increasing gap develop between rich and poor people. This prediction should be of serious concern in all Europe. Barreto and Barbosa (1998) point out that Portugal will need some thirty years to recover from this social reality. A recent study from the Social Sciences Institute, Lisbon University, (Barreto and Preto 1998) reveals that the Portuguese social indicators, between 1960 and 1995, do not show a social recovery similar to that in other European countries. Portugal must overcome this problem.

In these days of globalisation of economies, the domination of so-called industrial economies could be positive influence from an economic and social point of view (Euroconstruct 1997). A different perspective suggests that they could also represent a threat to the peace and prosperity, especially to the poorer countries. Within the capitalist system significant amounts of capital can move between countries very quickly. This movement can change the rules and balances and destabilise weak economies. Some emergent economies in the recent past such as China, Russia, India, and others in the Asia continent have, despite their involvement in the global framework of World Trade Organisation and the multilateral trading systems, been facing increasing economic problems. This could represent a serious threat to the globalisation of economics, and highlighting strong concerns with respect to sustainability.

The European Union economic growth has the benefit of western economy performance, with a growth in private consumption as well as increased investment. In the European Union employment is cause for concern but there has been an increase of 0.5% in the employment rate in 1997. This increase has been accomplished with a productivity rate increasing of 2.1 % (AECOPS 1998). Table 3.7 illustrates the employment and production rate performances. The need to create employment will be one of the priority objectives of European Union policy over the few next years. The construction industry may have a significant contribution in meeting this objective (ECIF 1998).

Table 3.7 – European Union employment and unemployment rates evolution from 1993 to 1998



Source: AECOPS (1998: 17).

SECTION 2: THE PORTUGUESE SITUATION

Construction Industry Situation

Before presenting a general description of the Portuguese construction industry situation and trends, it is important to provide some information about the characteristics of the sector and the legal environment for working in this area. Portuguese law requires all companies working in Civil Construction and Public Works, to obtain public licences or document (Inácio 1996). This licence named "Alvará", is a document, which confirms the suitability and capacity of the company to work in the sector. It is forbidden to lend, deal or to pass by any means an "Alvará" licence. Full details of the Alvará licence are in Appendix C (AECOPS 1995).

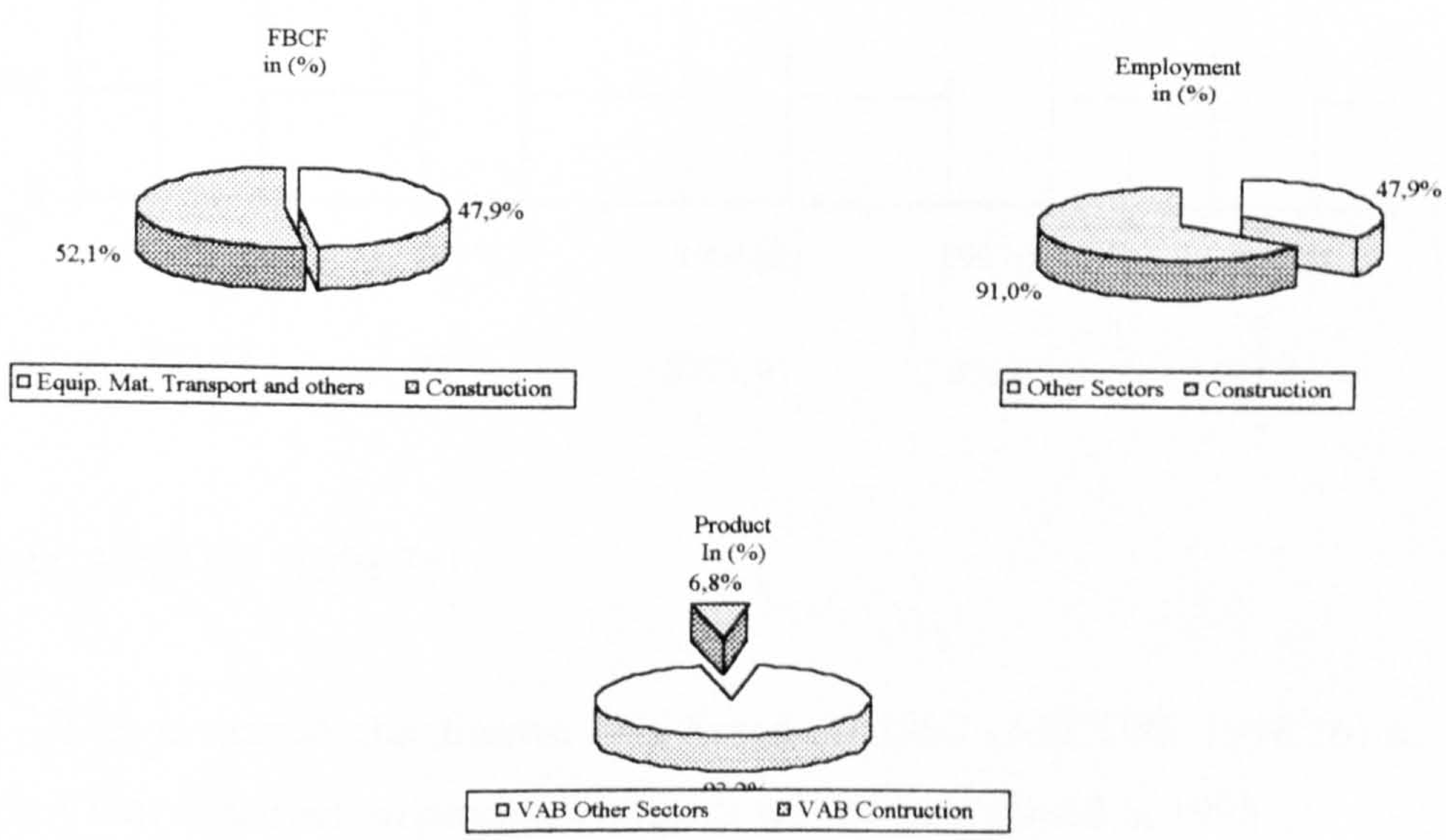
The Portuguese construction industry companies are also grouped into four main professional associations. Labour and other technical staff are integrated in different labour unions and they are grouped into two main unions confederations. The Intersindical Confederation is linked to left political positions and the União Geral de Trabalhadores (UGT) is seen as a confederation located in the social democratic political area. A description of the characteristics of the Portuguese construction industry and its trends follow.

Trends in the Construction Industry

According to the Portuguese report "European Construction to 2002" (Euroconstruct 1997), "construction output will increase at a higher rate in 1997 (+ 13.0%), as a result of the expected growth in the civil engineering segment (+ 15.0%) and the improvement in house building output. For the 1998/2002 period, total construction output will continue to grow at a lower pace (+4%). The completion of the large projects in Lisbon such as the Vasco da Gama bridge and the railway crossing over Tejo river significantly influence those figures. They will contribute to a slowdown in civil engineering output. Despite this, this activity segment is expected to continue to be the main engine of construction sector growth, with a 5.0% increase forecast for this period. The expected effects of the Economic and Monetary Union (EMU) in the reduction of interest rates, will have a positive effect in housing demand. Consequently, the house building segment will continue with a satisfactory performance, until the year 2002 with a growth rate of 3.0% being forecast for the 1998/2002 period."

In Portugal during the year 1996, the construction industry sector was the growth leader in the economy (AECOPS 1998). Figure 3.1 presents the construction sector weight in national economy during the last ten years. According to the monthly surveys of construction activity and results from the National Statistic Institute (INE 1998), construction companies activity level has been positive during 1997 and is forecasted to remain so during 1998.

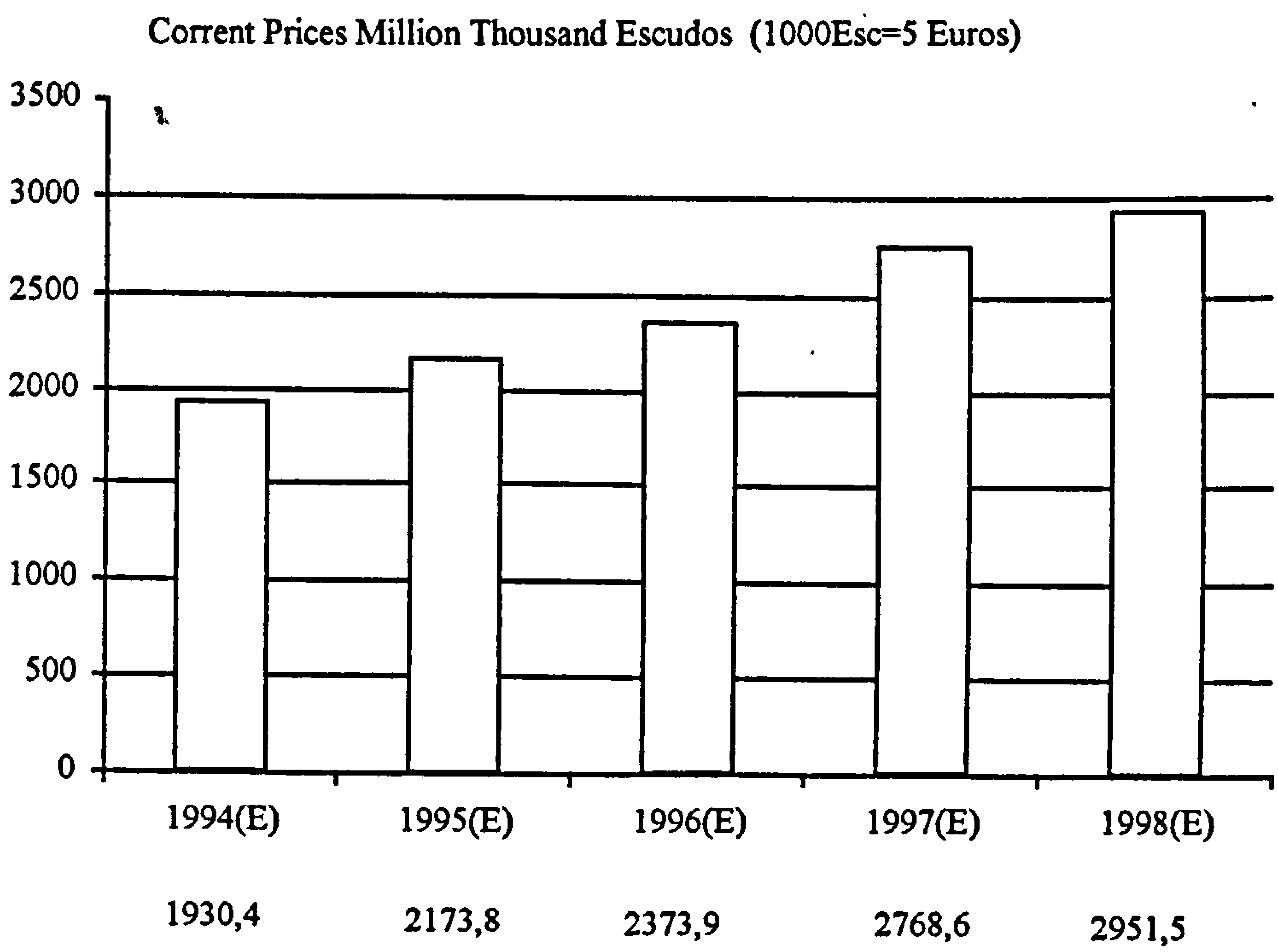
Figure 3.1 – The Construction Sector weight in the Portuguese economy from 1988 to 1998



Source: AECOPS (1998: 25).

There is some debate about the 1998 forecast (the actual figures are not yet available). Some forecasts for 1998 show growth slowing as the number of big civil engineering works, such as the Expo'98 works, the Vasco da Gama bridge (referred to earlier) and new motorway constructions come to competition. Other forecasts suggest that new investments such as the Alqueva dam and surrounding works will offset the influence of the completed works and that the level of production will continue to grow. Table 3.8 presents the level of production in million of "contos" (one "conto " is equivalent to one thousand escudos) from 1994 to 1998.

Table 3.8 – The Portuguese Construction Sector production evolution from 1994 to 1998



Source: AECOPS (1998:26).

This is ranged quantitative data based on 1997 (AECOPS 1998:26) to support the view that construction production levels will be maintained in 1998.

- Cement consumption increased 13.8 % in 1997 compared to the prior year exceeding 9.4 million of tons.

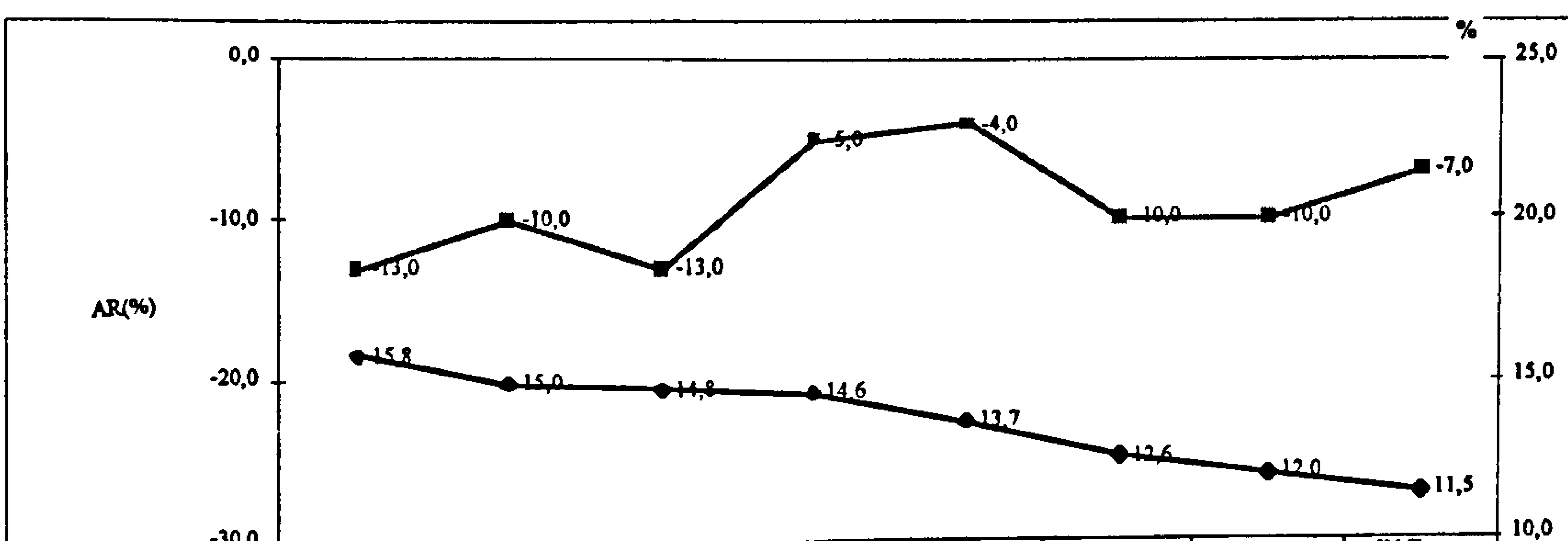
- Steel sales (to reinforced concrete) increased 23 %, from 1996 to 1997, exceeding 817 thousand tons.

- The number of workers in the sector increased 13.2% compared to the previous year.

- The production volume increase and reducing interest rates in financial markets (AECOPS 1998) also support the forecast.

Table 3.9 shows the financial situation of construction industry companies and the relationship between the financial situation and the lowering of interesting rates from the years 1996 to 1997. This resulted from the harmonisation of interest rates leading up to the launch of the Euro.

Table 3.9 – Construction companies' financial situation and bank loan rates 1996 and 1997



	I Trim/96	II Trim	III Trim	IV Trim	I Trim/97	II Trim	III Trim	IV Trim
Financial Situation	-13,0	-10,0	-13,0	-5,0	-4,0	-10,0	-10,0	-7,0
Bank Loan Rates	15,8	15,0	14,8	14,6	13,7	12,6	12,0	11,5

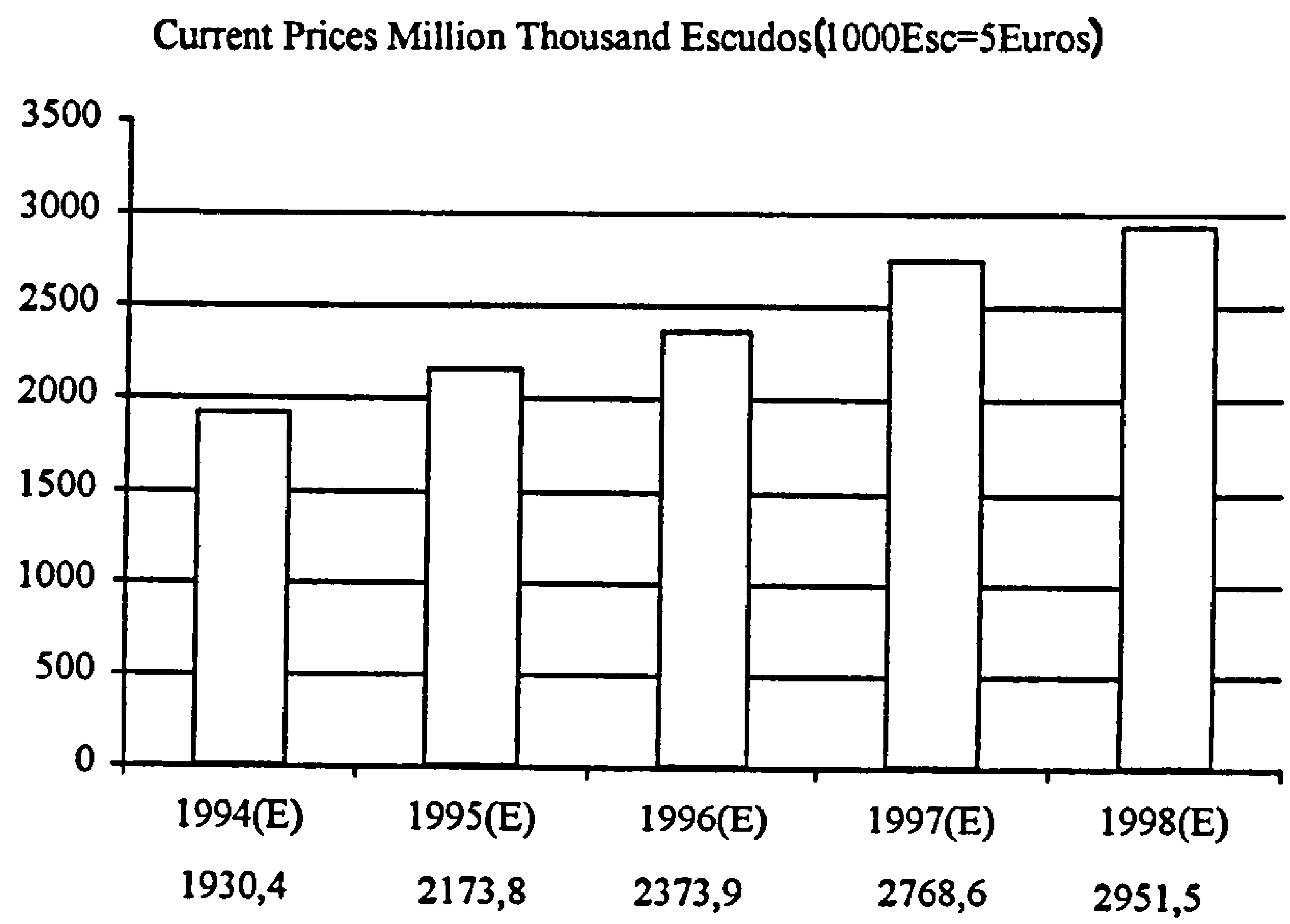
AR= Answers rate

Source: AECOPS (1998:29).

The construction industry production record in Portugal has been significant. Table 3.10 illustrates the production increase in the sector in the last four years. Table 3.11 presents a classification structure for the Sector in 1997. The classifications are New Residential Buildings, Non Residential Buildings, Civil Engineering and others.

According to the ECIF report (ECIF 1998), New Residential Buildings output grew sharply during 1997 with a rate raising by 10% from the prior year. This strong housing demand was influenced by the most favourable financial interest rate of this decade. The number of mortgage loans increased by 29% and their combined value, increased by 36% when compared with 1996.

Table 3.10 – Construction Industry production in Portugal from 1994 to 1998

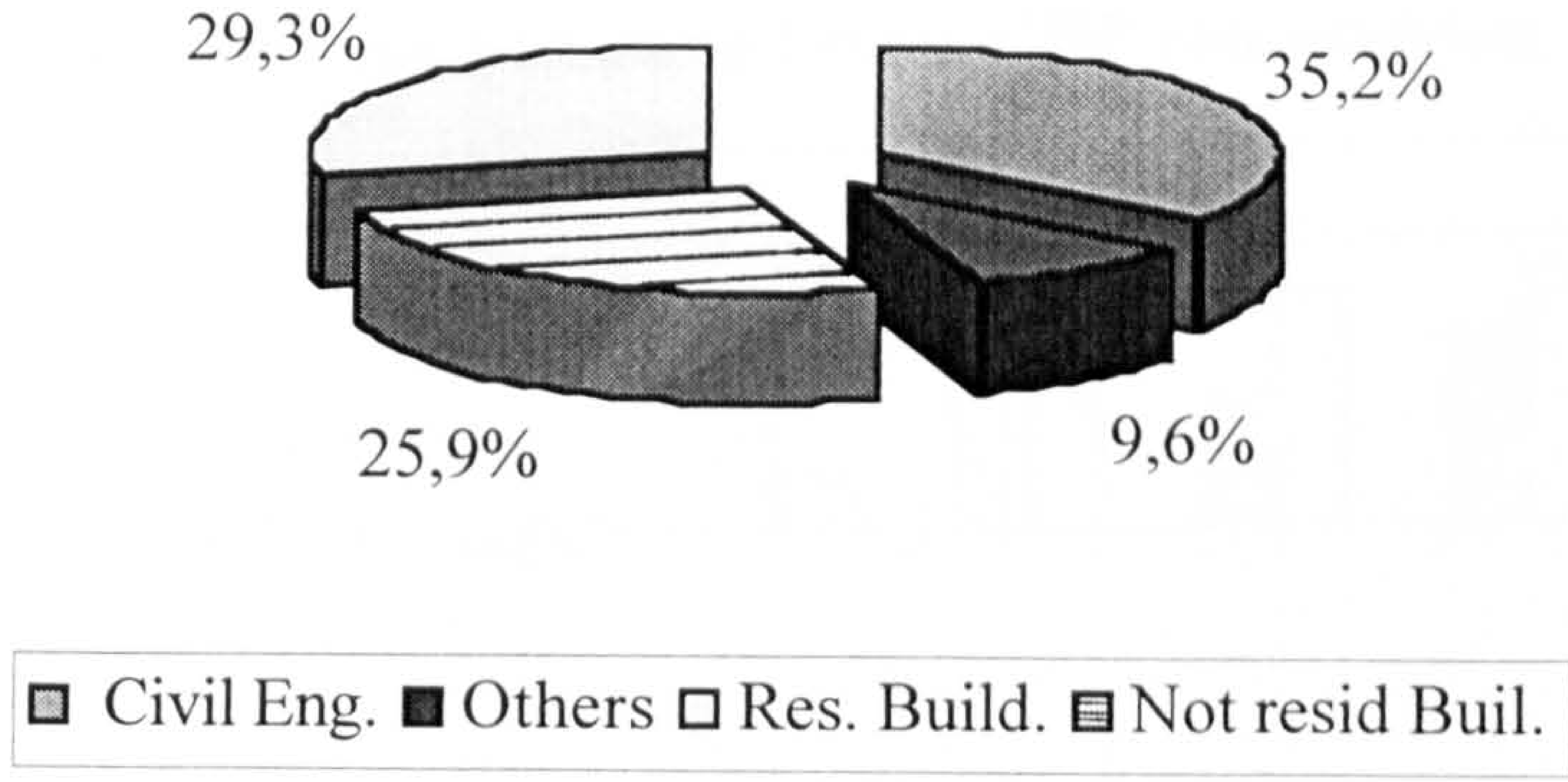


Source: AECOPS (1998: 26).

The employment rate increased 1.9%, compared with the prior year. This relates to non-residential building output. The prediction for private non-residential building was for a rise of 8.5% and public building output to rise by 14.5%, comparing with 1996 (ECIF 1998: Portugal: 3). The figures are not yet available to confirm these predictions.

The civil engineering segment was predicted to grow in 1997 by around 15.5%. That growth is a result of the size of the projects as well as the global expansion of the economy. The ECIF report also predicted that the rehabilitation and maintenance segment would rise at a rate of 7% in 1997. In total the building construction and civil engineering sector has been growing at a rate of 13% during 1997, compared to the previous year (Euroconstruct 1997: 245). This growth is a function of the low interest rates, as noted previously for the housing sector, which has pushed up market demand. Table 3.11 presents the production structure of the construction industry sector in 1997.

Table 3.11 – Construction Sector structure in 1997



Source: AECOPS (1998:27).

According to information and data from INE (INE 1998), the economic activity in Portugal was dynamic in 1997, with a GDP growth rate about 3.5 %. This growth was the greatest in the 1990's and reduced the differential between the Portuguese economy and other European Community countries.

Table 3.12 presents the GDP rate growing in Portugal and the European Union between 1992 and 1999. The Portuguese economy has been had in the last years a good performed well over the last few years. It is the result of some significant factors that were highlighted in the discussion of the construction industry sector. Some very important works were assisted by European Union financial funds. In the context of this research the main sources for funding waste management projects in the Community are:

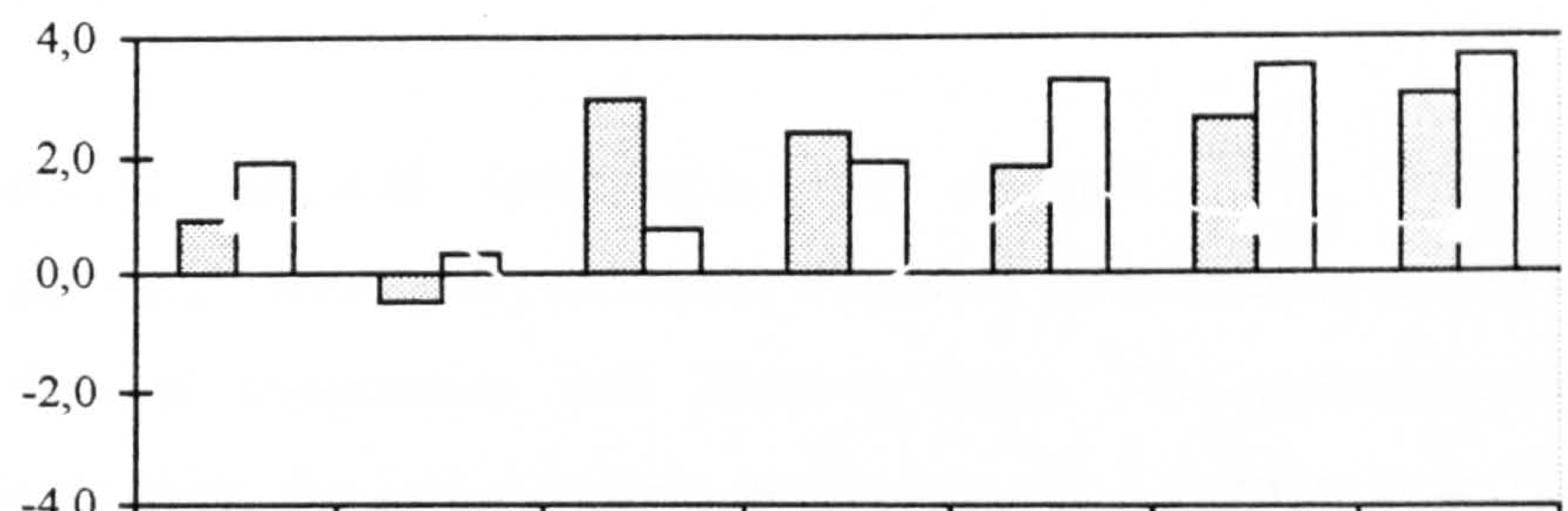
- European Investment Bank

- European Structural Fund

- European Cohesion Fund

The European Investment Bank's contribution to environmental projects mostly takes the form of low interest rates loans. There are other forms of support, such as the co-financing of environmental projects to third countries (EC 1996a).

Table 3.12 – Portugal and the European Union, GDP rate growing



	1992	1993	1994	1995	1996	1997 (E)	1998(P)
CE	0,9	-0,5	2,9	2,4	1,8	2,6	3,0
Portugal	1,9	0,3	0,7	1,9	3,3	3,5	3,7
Diferencial	1,0	0,8	-2,2	-0,5	1,5	0,9	0,7

Source: AECOPS (1998:19).

Funds from the European Union have been fundamental in helping Portugal move to a different level of development and performance. This is true in a diversity of activities that contribute to the indicators of development and performance. It is particularly true in environmental activities directly addressing sustainable management issues.

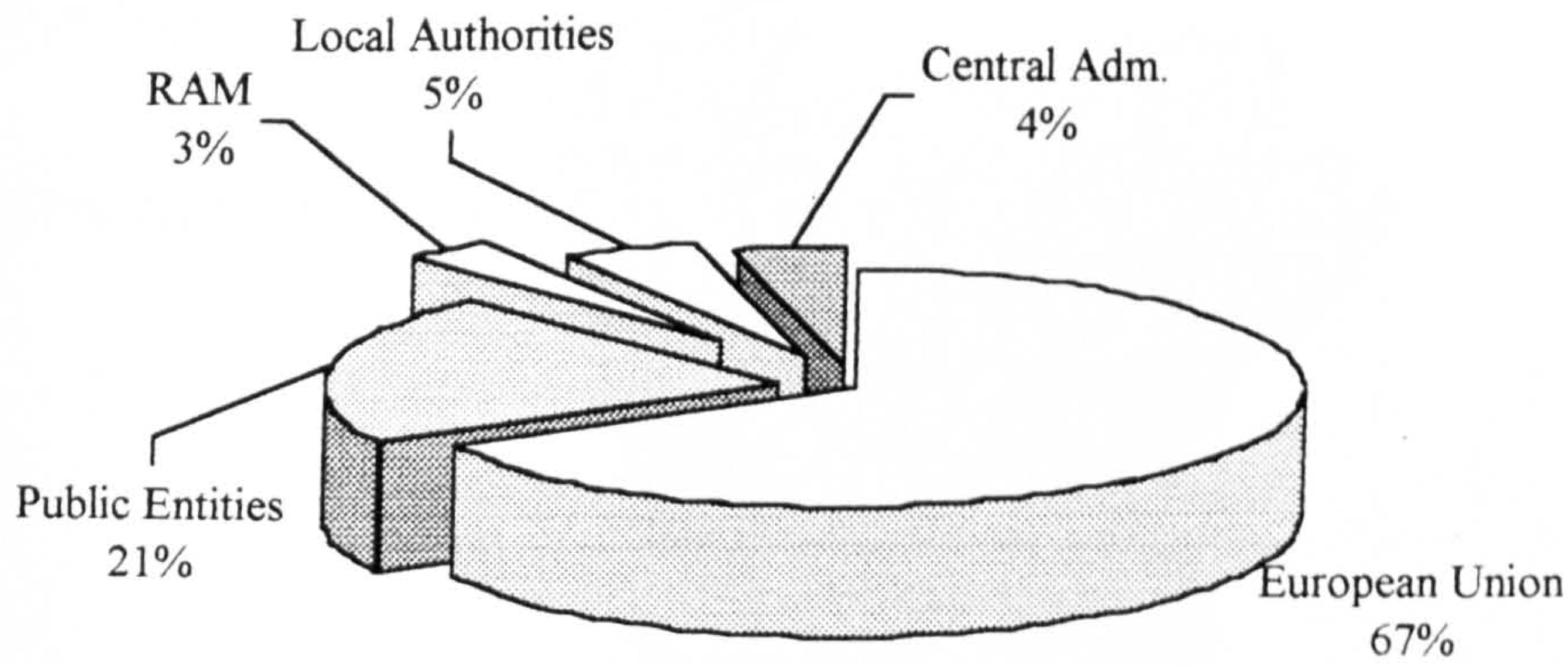
Funds

Both the European Regional Development Fund and the Cohesion Fund may be used to finance projects related to the environment sectors, including waste management. The funds can be granted for up to 85%, a relatively high percentage, of the total project cost. These funds are not directly administered by the Commission, but by competent national authorities.

Sector-specific financial instruments (for example LIFE, SAVE, 7th Environmental Research Programme) are funds, which are directly administered by the Commission, often in co-operation with Member States. The importance of the financial assistance from the EIB has been stressed in the Cohesion Fund (DGDR 1998). This reflects community participation in the efforts developed by the four Cohesion countries to reach community average development and performance levels. The four Cohesion countries, Portugal, Spain, Greece and Ireland, have a GNP per inhabitant that lags 90% behind the European Community GNP average. The Cohesion countries must comply with the convergence programme funded by the financial instruments. They must also adhere to budget restrictions required by a programme that is designed to meet the economic convergence criteria, described in article 104 of the Mastrich treaty.

The Cohesion Fund is exclusively focused on the transport and environment fields, and aims at supranational objectives. In the environment field, the objective is to safeguard the common heritage and the improvement of performance levels in basic services, which will benefit all the populations of the Cohesion Fund countries. National participation is divided among various bodies and shown in Table 3.13.

Table 3.13 – Financing sources for projects approved by the Cohesion Fund



RAM - Regiões Administrativas Metropolitanas. Administrative great areas.

Source: DGDR (1998 : 5).

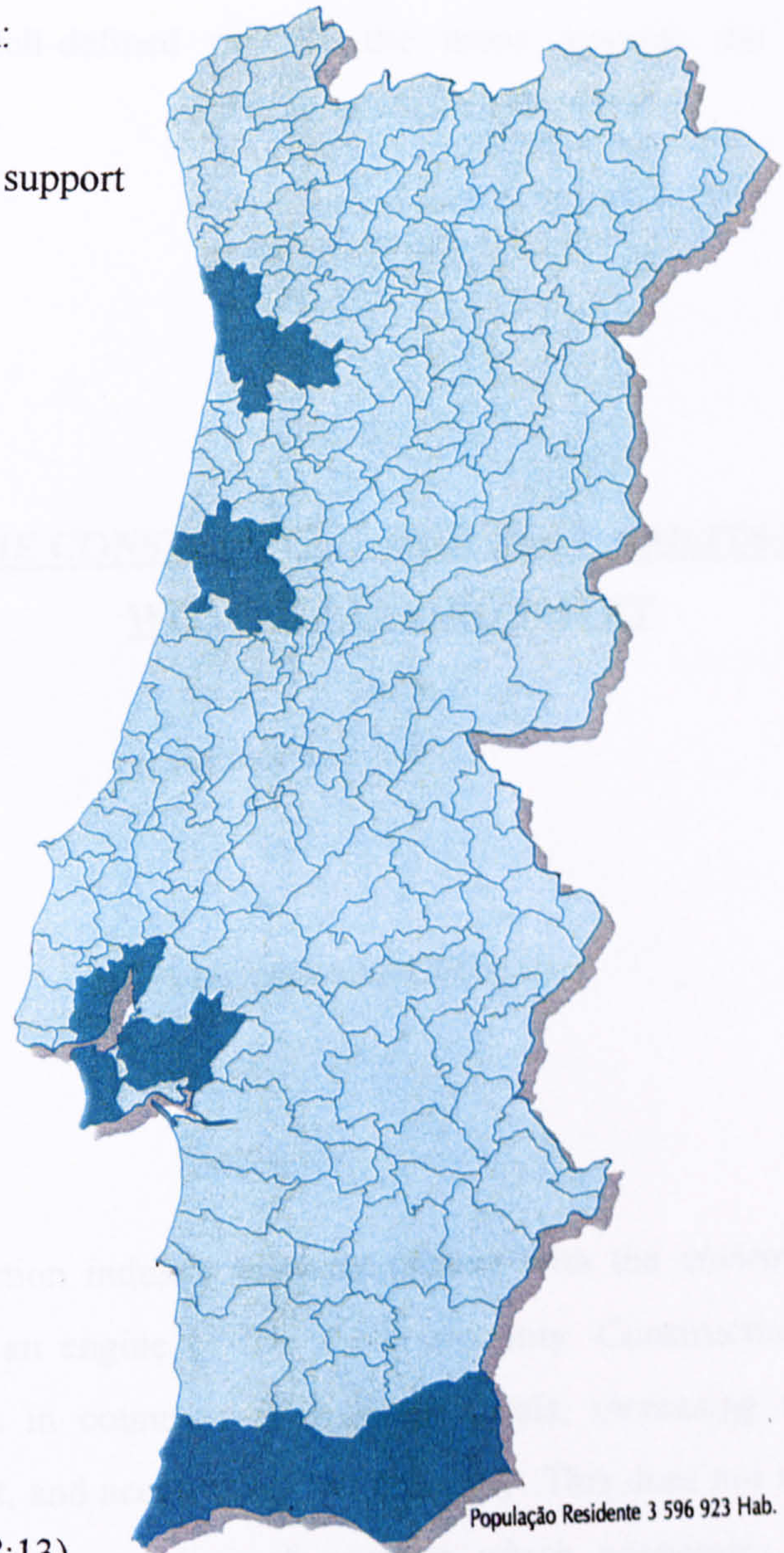
The Cohesion Fund rules and objectives have been applied in waste management for certain geographic areas only. These areas have large urban concentrations. In Portugal, these areas are on the coast and in the south of the country and are shown in Figure 3.2.

The strategy adopted by Portugal to obtain these funds requires the involvement of national resources. These resources not only include the financial resources of the Portuguese Government, but also other resources in the country that will ensure the long-term efficiency of the projects. Generally, fund assistance will not exceeded 67% of total cost. In terms of waste management entities, the country has found a solution supported by the Multimunicipal system. The Public Administration in the form of a public holding entity, the Empresa Geral de Fomento (EGF), shares the capital jointly with some municipalities forming a specific entity (EGF 1996).

Figure 3.2 – Areas with financial support from the Cohesion Fund

Municipalities with:

■ - Cohesion fund support



Source: DGDR (1998:13).

The strategy adopted by Portugal to obtain these funds requires the involvement of national resources. These resources not only include the financial resources of the Portuguese Government, but also other resources in the country that will ensure the long-term efficiency of the projects. Generally, fund assistance will not exceeded 67% of total cost. In terms of waste management entities, the country has found a solution supported by the Multimunicipal system. The Public Administration in the form of a public holding entity, the Empresa Geral de Fomento (EGF), shares the capital jointly with some municipalities forming a specific entity (EGF 1996).

Development (EC 1992b). In an overview of the programme it was stated that the funds make the link between environment and development. In this context the construction industry has a well-defined role in the move towards the environmental and sustainability goals.

SECTION 3: THE CONSTRUCTION INDUSTRY AND ITS INTERACTION WITH THE ENVIRONMENT

Principles and Concepts

The construction industry interacts closely with the environment; it makes a contribution and is an engine of the world economy. Construction industry activity increases businesses in countries at different levels, increasing the national GDP, creating employment, and accelerating the economy. This does not mean that the basic concerns about the understanding of ways in which economies and environments interact and their interdependence has been achieved. Economy and environment must be partners in sustainable development strategy. Agenda 21 invited all countries and all sectors of society to participate in the formation of effective national strategies for sustainable development.

There are concerns about the development of sustainability in practice. These are new and emerging concepts for the construction industry. Sustainable construction has also been referred to as green construction. This concept of "green" construction covers a large spectrum. It has developed into a large debate as Cook (1995) points out in her work from Transpersonal Ecology to the Cornucopian Environmentalist (Figure 3.3).

Figure 3.3 – The Green Spectrum classified under Ecocentrism and Technocentrism views

ECOCENTRISM			TECHNOCENTRISM	
Transpersonal ecology	Deep ecology	Moderate ecology	Accommodation environmentalist	Cornucopian environmentalist
No action	No action	Action	Action	Little Action
	Extreme preservationist	Resource preservation	Resource conservationist	Resource exploitation
	Heavy regulation	Very deep green economic incentives (Eis)	Managerial, modified economic growth	Unfettered markets, max GNP
Population cull	Reduce population	Zero economic & pop'n growth		
«religious» belief	Bioethics, intrinsic value	Primary value of eco-systems	Intra & inter-generational equity	Support for traditional ethical reasoning
			Instrumental value in nature	Rights of humans
			Anthropocentric	Anthropocentric
	Ecological laws dictate morality	Self reliance	Improve min. level of environmental legislation	«man» solve social political, & technological problems

Source: Cook (1995:63).

In 1993 a UK consultant firm, Ove Arup & Partners published a Green Construction Handbook, a manual for clients and construction professionals based on a research project entitled Going Green (Ove Arup & Partners 1993).

The term sustainable construction was originally proposed to describe the responsibility of the construction industry in attaining "sustainability" in a personal communication, on 6 December 1993, by Prof. Charles Kibert and referred to by Richard Hill, Jan Bergman and Paul Bowen (Hill, Bergman, and Bowen 1994: 17).

The subject was discussed in depth in a conference at Tampa California in 1994. The proceedings were published by Kibert (1994a) and established the principles, criteria and the main features of the concept of sustainable construction.

The conference was convened by CIB Task Group 16 led by Prof. Kibert and was the first world conference to address these issues. The key presentations and reflections highlighted the major challenges for the construction industry to act on its obligations to achieve sustainability. Kibert (1994a) argued that the first task was to analyse traditional construction approaches and to compare them with the new sustainable criteria for building materials, products and systems. He concluded that the traditional criteria for the analysis of construction is based on performance, quality and cost indices. The analysis of sustainable criteria is base on issues of resource depletion, environmental degradation and a healthy environment. The construction industry will need to include these new indices to enable it to act on its obligations to achieve sustainability.

The most difficult issue to pursue is to define the criteria and options in a model that can serve as a tool to indicate to the construction industry appropriate alternative options for materials, products or systems. Kibert (1994a) further argued that the first steps in the process was to establish sustainability estimating and assessment tools. These will need to include the issues that are encompassed by the sustainable construction concept. They are proposed at follows:

A. Resources – Energy consumption, Water use, Land use, Materials Selection

B. Healthy Environment – Indoor Environment Quality, Exterior Environment Quality

C. Design – Building Design, Community Design

D. Environment Effects – Construction Operations, Life Cycle Operation, Deconstruction

Initially in order to determine appropriate decisions that will improve the creation of the built environment, technical criteria are often applied to the materials selection process. Reducing these to easily manageable information produces essentially three overarching criteria based on:

". Embodied energy content

. Greenhouse warming gases

. Toxic substances generated/content"

Each of these criteria has the difficulties in their application concerning the necessity to harmonise the practical and scientific positions. The principles for sustainable construction must enable all the actors involved from developers, planners, architects and engineers, to builders and operators, to interiorise these new attitudes and behaviour. That is to say that the inclusion of these issues in the decision process, must become automatic and intuitive. They have been defined (Kibert 1994a) as the "Principles of Sustainable Construction, which are:

- Minimise resource consumption (Conserve)

- Maximise resource reuse (Reuse)

- Use renewable or recyclable resources (Renew/Recycle)

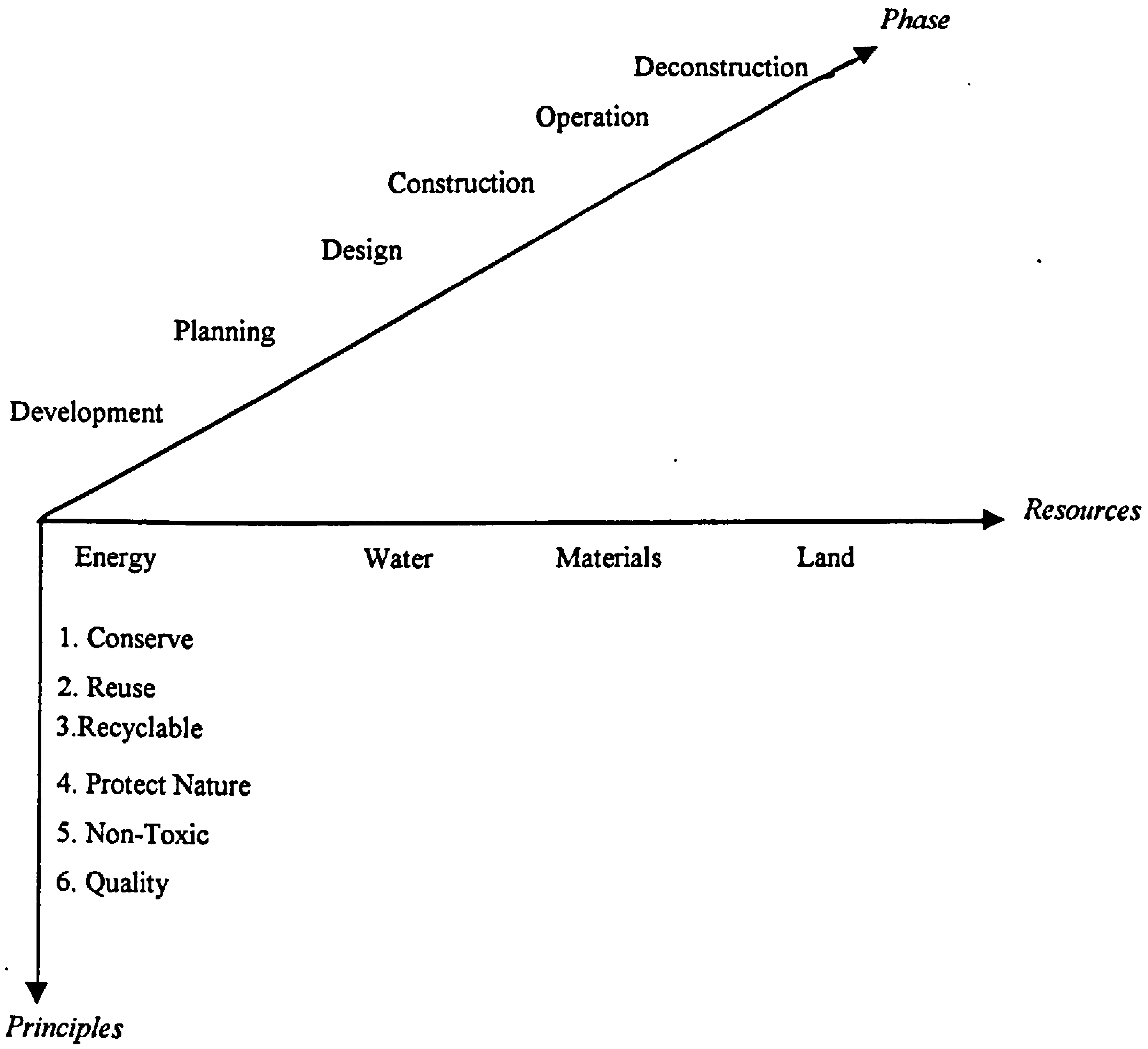
- Protect the natural environment (Protect nature)

- Create a healthy, non-toxic environment (Non-toxic)

- Pursue quality in creating the built environment (Quality)"

These six principles has its complexity and a number of ramifications that must be explored in order to understand the global context of these new positions. This new relationship between development and environment where the construction industry is the link is very important and make a significant contribution to the towards the sustainability agenda. Kibert (1994a) has developed a conceptual model for sustainable construction combining these principles and the resource and time dimensions. This model is presented in Figure 3.4.

Figure 3.4 - A conceptual model for Sustainable Construction



Source: Kibert (1994a Fig.2).

The detailed development of the model shows the principles referred to and the resources to which these principles must be applied. It also links with the stages or phases of the building life, the time dimension, during which these applications must occur. This concept model has the key objective of correlating and articulating the issues which are at the heart of the sustainable construction concept.

In summary, the construction industry will inevitably change its current construction methods of operating. These methods pay little regard to the environment impacts of the operations. The new methods will take heed of environment concerns. They will need to consider the impacts at each stage of the building life and act accordingly to minimise those impacts. In Design for Environment, Graedel and Allenby (1996) discussed the process from design to deconstruction including reuse and recycling and utilising these new concepts. Other authors have also addressed these issues. Fox and Murrell (1989) published a guide to the environmental impact of building materials. Thomas (1996) published an introduction to environmental design for architects and engineers where he reflected and made suggestions for a new environmental design approach which followed the sustainable construction concepts. There are many more.

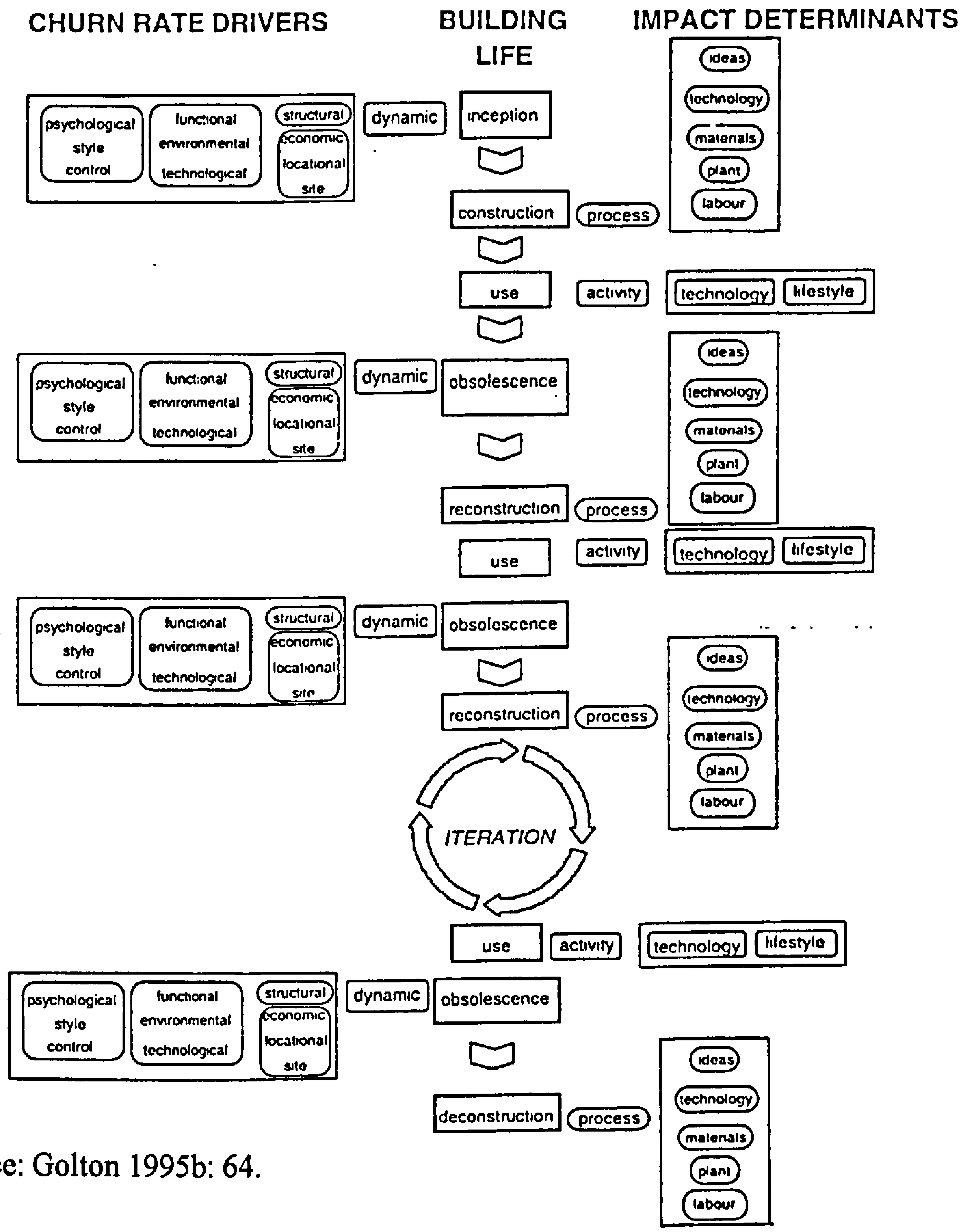
In many countries, construction and the related supply industries make a major contribution to the GDP and to the gross fixed capital. The size and diversity of the sector give it a widespread influence on sustainability issues. It is a major user of resources and materials, both in the construction process and in the use and maintenance of buildings, and other civil engineering works.

The previous chapters highlighted that the outputs from the construction industry were a manifestation of modern society lifestyles and preoccupations. The interaction with natural resources depletion, energy consumption and impacts was also highlighted. As Golton (1995b: 64) points out, the processes and activities which create impacts, need to be considered together in a global and dynamic overview, with a special attention to the frequency which the impacts producing process occurs. The impacts of human activity were studied focused on the impacts and the relationships between consumption, affluence and technology. These issues, in the context of building were studied by Golton (1995b) by developing a conceptual model of the life cycle of buildings and its relationship with building structuring impact issues.

The conceptual model on which this is based is presented in Figure 3.5. Its analysis suggests the dynamic and interaction in building life span. This building life cycle drives the reconstruction and obsolescence phase, and finally the deconstruction of the building. These processes and activities are associated with the global overview as they create impacts, are also studied with its components and all these three factors, dynamics, process and activities. All of them contribute to the understanding of the qualitative and quantitative characteristics of this issue.

Figure 3.5 demonstrates the building cycle, where the processes and activities, which create impacts, are correlated with the dynamics, the frequency with which the impact producing process occur. The frequency at which reconstruction or deconstruction occurs, the churn rate drivers is driven by obsolescence. This is posited as the dynamic of building. This dynamic is made up of a group of issues, or perspectives, which drive the decision to construct the building, to reconstruct it during its lifetime, and to deconstruct it at the end of its life. These issues can be categorised into four perspectives. First, the structural issues, which concerns the fabric of the building, second, the financial group concerning economic returns, location and site perspectives. The third group concerns the utility perspective and the last group, concerns social perspectives, of psychological, style, and control issues.

Figure 3.5 - A conceptual model of building – structuring impact issues



Source: Golton 1995b: 64.

The issue involved at the process stage may be categorised as ideas, technology, materials, plant and labour, and are related to construction, reconstruction and deconstruction activities. Lifestyle and the technologies, which support it, constitute the activity, which is directly linked with the use of the building.

This is a picture of a complex set of relationships where quantitative and qualitative data are directly linked and directly driving the impact of the building, or changing the pace at which impacts occurs. This relationship, and this inter activity with the building life cycle "from cradle to grave", needs to observe the concepts and principles of sustainable construction, in order to move towards sustainability. A position where new environmental attitudes and behaviour must work together with the economic view of reality. This new overview of the life cycle of building, driving forces and impacts, gives insight into the new attitudes that are needed in design and practices in construction. Changes which are necessary to achieve those objectives.

SECTION 4: CHANGES TOWARDS A SUSTAINABLE CONSTRUCTION CULTURE AND ATTITUDES

A Global Overview

Change towards a sustainable construction culture and the associated new attitudes, must be adopted in a dynamic and a global approach. The strategy must involve all the actors in civil construction projects and guide them to the common ends. Those ends posited in the Programme of Action for the Environment and Development from Agenda 21, and European level from the Fifth Programme for the Environment and Development, must be adopted and applied. This requires the involvement of all the actors, affected by a project, in the decision processes leading towards sustainability.

The sustainable construction model from Kibert (1994a: 10) illustrates the issues which need to be addressed and the changes which need to be made. The changes must be part of a sustainable development strategy. The UK Sustainable Development Strategy (Sustainable Development, the UK Strategy 1994) is one example of such a strategy. It is a government document, which outlines the framework for construction and the built environment in the context of sustainability. The main issues posited are:

- To refurbish, adapt and reuse existing buildings

- To design and construct new buildings which can be adapted to different uses, thereby extending their lifetime

- To use recycled components and materials, or those from sustainable resources

- To minimise the energy needed to operate a building

- To reuse or recycle waste produced during construction and demolition

These statements are fundamental guidelines to create a new philosophy of sustainable construction. Another report from Construction Industry Research and Information Association (CIRIA 1995a), has highlight other key environmental issues. These are:

- Management and Responsibility – the management of the process and responsibilities of those involved must ensure that environment issues are addressed in a thorough and rigorous way.

- Procurement – Ensuring the selection of professional advisors committed to an environmental approach that is essential to achieving greener construction. The right brief and contract procedures will also make a significant difference to overall impact of the finished article.

- Complying with law – UK and EC legislation and regulations on the environment are increasing and tougher requirements are being set. Those involved must be aware of their responsibilities.

- Transport – Increasing emphasis is being placed on minimising high-impact transport requirements, and the need for reducing non-pleasure travel in order to reduce the requirement for environmentally damaging infrastructure and the associated pollution.

- Local Environmental – Involving interested parties at an early stage will have a beneficial effect on projects. Local issues can delay projects, if they have not considered them adequately in the site appraisal.

- Internal Environmental – The quality of the internal environmental (e.g. cleanliness, ambience, aesthetics, noise, controls, air and light quality) has been shown to have a profound effect on the health and productivity of building users. A "good" building promotes a good response.

- Energy – The use of fossil fuels releases carbon dioxide and other pollutants into atmosphere, contributing amongst other things to global warning. Minimising energy need, improving utilisation and considering renewable sources at the conceptual design stage of a project, can reduce pollution and running costs, and need not cost more.

- Water – Water is an increasing cost to building operators, and there are concerns about its quality and its potential impact on health and hygiene. Conservation measures should be considered alongside health matters.

- Materials – The materials and products used in construction projects can affect the environment through resource depletion, pollution, and risks to health and safety generated during the production of the raw materials, manufacture, transport, use and ultimate disposal.

- Waste – Waste squanders resources, and waste disposal is becoming increasingly difficult, due the lack of space for new landfills, transportation costs, and the increasing awareness of environmental issues. Reducing waste has financial and environmental benefits.

– Maintaining your investment – Low capital cost at the expense of maintenance and running costs, can be a false economy and may shorten the project's productive life. Addressing environmental issues at an early stage, and giving full consideration to capital, maintenance and running costs maximises the value of your investment.

This global overview towards sustainable construction, with different attitudes and behaviours with regard to the environment, needs to adopt strategies and criteria in order to pave a different way to the future.

The Way Forward

The way forward will be to put into practice in a phased approach, all these principles, with the essential support from all actors, in a sustainable and integrated framework. A UK document from 1990 (CIRIA 1990) states that the construction industry must re-orientate to meet these significant environmental challenges. It restated the view that it will be necessary to have a national sustainable strategy. Work undertaken by The Institution of Civil Engineers in co-operation with the Association of Municipal Engineers in 1991, observed that 80% of the landfill arising were from construction and demolition wastes and general industrial/commercial wastes. Household waste was responsible only for 20% of total waste arising. They suggested recycling as the way ahead (ICE/AME 1991).

Portugal has recently established a Sustainable Development Commission. This was defined in the new Ministry of the Environment Organic law by the Decreto Lei nº 230/97 from 30th of August 1997, but was only implemented in 1998. The necessity of implementing a National Sustainable Development Commission has been highlighted by a significant group of stakeholders and actors involved in the process (Águas e Resíduos nº 6, 1997).

Lessons concerning sustainable development from other countries, for example the UK, should be learned. The document "Sustainable Development, The UK strategy" (Sustainable Development, the UK Strategy 1994) is a starting point for the debate and presents an approach to achieve sustainability. Chapter 25 sets out the approach. A sustainable framework for the construction of the built environment, it posits, involves refurbishment, adaptation and reuse of existing buildings. It reinforces that approach by suggesting that new building should be designed with that consideration in mind. It further suggests that the minimisation of energy needs and the reuse and recycling of components and materials and obtaining resources from sustainable sources are desirable. These are all approaches which have been discussed earlier.

In dealing with trends it states that "There has been a continuing improvement in the energy efficiency of buildings, driven by building regulation requirements, recognition of the environmental and financial benefits of reduced energy use and improvements in technology and techniques. Technology is also improving the ability of designers and constructors to use sustainable and recycled components, and to reuse and recycle construction wastes."

It follows that observation with one on "Problems and Opportunities". It states "Practices such as energy efficiency, recycling and use of sustainable materials and products need to become inherent parts of the design and construction process and, in some cases, to displace traditional construction techniques and practices. The process has already begun, promulgated through a number of channels such as design leadership, education and training, regulation, research and development, and dissemination of information."

The following paragraph deals with "Current Responses" and states: "Research and Development activities are continuing into energy efficiency techniques, technology and best practice. Results are being disseminated. Research is also being undertaken into recycling opportunities.

The BREEAM environmental assessment methodology is continuing to make progress, with new applications under development. Training and career development programmes for building professionals are increasingly taking on board the principle and practice of environmental sustainability in the construction process, although further progress in this area is desirable."

The final paragraph of the summary "The Way Forward" states that: "improving standards of thermal performance of buildings are planned under the Building Regulations. Further initiatives are needed between Government and the industry to bring forward ways of increasing recycling and minimising waste in the construction process."

The need to address the waste issues, the focus of this research, are again highlighted in these proposals. These reflections and suggestions from the UK sustainable development strategy could be immediately adopted and followed in Portugal. They are apposite to the Portuguese situation. The country's public authorities have a duty to identify key issues facing the industry in its efforts to meet global infrastructure needs, in an economic and environmentally responsible manner. A report from the USA develops these ideas (CERF 1996a):

> "- Applying global standards and performance criteria. This means to develop uniform international standards and methods that reflect performance considerations, which are necessary for the construction industry to have the flexibility to innovate internationally.
>
> - Utilising demonstration projects to accelerate innovation. Demonstration projects are an effective tool furthering sustainable development concepts. There is a recognised need for an organised, international approach to identifying appropriate projects to serve as demonstrations, formalising observation of those projects, verifying the performance of sustainable

technologies in real world applications, and disseminating the results broadly and to specific target audiences.

- Expanding the industry's knowledge base. Enhancing the industry's knowledge base is essential for industry to have the information necessary to design and build appropriately and to make sound decisions.

- Streamlining the construction process. All phases of the construction process must be made more receptive to innovation and the various phases more thoroughly integrated. The need for streamlining ranges from revamping the legal and regulatory context for construction to the need for consistent and timely information on the construction side.

- Creating new analytical tools and methods. In addition to creating a knowledge base, new tools and methods are required for advancing state-of-the-art technologies, including taking advantage of advances in information systems and telecommunications to increase the construction industry's efficiency and productivity, creating life-cycle costing techniques, and developing databases.

- Bringing understanding to industry, government, and the public. Public information, education, and more fundamentally, understanding, are key components of a global research strategy. Promoting understanding, not only within the construction industry, but also among the customers of the industry. It is also necessary so as to establish an atmosphere that is conducive to innovation.

- Defining sustainability operationally. A key step in implementing the research agenda is to define sustainability in operational terms. Before the construction industry can act to create sustainable infrastructure with confidence, there must be a clear, accepted delineation of the ways to identify, evaluate, and verify sustainability."

This report reinforces the positions taken by others in seeking the way forward to towards a sustainable approach. It lays weight on the need for education and the involvement of all the actors in the process. The involvement of stakeholders and decision-makers is fundamental to the achievement of sustainable goals. It is a multidisciplinary approach where all specialities and interests should have their proper space. This includes for instance the social and psychology disciplines which represent the new views in public, technical and scientific participation.

The Importance of the Stakeholders and Decision-Makers in the Construction Process. The Psychology and Social Sciences Role

The sustainability agenda from an ecological and economic perspective discussed in the previous chapter together with its relationship with social, political and environmental perspectives. The overview of the construction industry spanned from consideration of all the actors involved to consider the life of buildings from the inception to deconstruction. It was shown that all the aspects of a buildings life must be studied and related to changes in patterns of human development, production and consumption. This knowledge is helpful in understand and contributing to the practical implementation of this new paradigm. A difficult area concerns attitudes and behaviour (Dawes 1980). Loftness et al. (1994) studying sustainability in the built environment, have used different categories fur their studies which they have developed into six guidelines. These guidelines form the structure for the long term research, development and educational efforts of the Advanced Building Systems Integration Consortium

(ABSIC)[5]. The six categories are Process, Fabric, Resources, Shell and Core, Materials, and Life Cycle.

- Process: This must involve an integrative approach and must develop a sustainable design built on integrative, multi-disciplinary design process in lieu of the conventional linear, disciplinary process. It must emphasise the:

  . understanding of the material and the energetic information of entities and processes.

  . emphasise the systemic nature of environmental relationships, and

  . propagate an integrative approach and adaptative-iterative strategies.

- Fabric: This includes transportation and infrastructure and in sustainable design is dedicated to rebuilding mixed-use pedestrian neighbourhoods; capturing existing natural and built amenities, in lieu of further new land consumption with single use zoning.

- Resources and Climate: This includes issues of locality and massing. For sustainable design the resources used for the building fabric should be found locally and the massing of the buildings should maximise the natural energies of the climate and minimise the impacts of entry and exiting the buildings by the users.

- Shell and Core: Sustainable buildings will merge natural, low resource solutions of the past (daylight, natural ventilation, natural heat and air exchange, direct environmental contact) with high technology integrated system advances and expert system controls for humanising the workplace.

[5] The Advanced Building Systems Integration Consortium, an Industry-University-Government consortium, dedicated to advancing the quality and performance of buildings.

- Materials: Sustainable Buildings are built and refurbished with appropriate, non-polluting materials, assembled as systems, with low embodied and low operating energy, as well as high durability, reusability or recyclability.

- Life Cycle value: Sustainable buildings and communities are designed for life cycle value, replacing least cost, tight fit, with generous designs, modifiability through modularity and integration.

These categories, whilst based on physical criteria demonstrate the need for paradigm changes in the approach of those involved in the building process. It is necessary to translate these broad agendas into concrete recommendations, tailored to address the needs of architects, planners, engineers and all the actors involved in construction industry planning.

These global imperatives serve to describe the situation from an institutional and political point of view. It is not sufficient to explain individual or group motivation (Quercus 1993: 10), to adopt more favourable behaviour to achieve sustainable construction principles and practices.

An understanding of social and environmental psychology (McCornack 1993) will drive the lifestyle changes necessary for an environmental friendly alternative. The importance of human attitudes and behaviour are central to this issue. It must be stated that the relationship between attitude and behaviour is not direct. The same behaviour in different people could be associated with very different attitudes.

For example, to recycle construction and demolition waste could be driven by an environmentally friendly attitude, or an economic or legal obligation, or the scarcity or new construction materials.

The new sustainable construction paradigm requires different behaviour patterns to be developed with the involvement of all the actors, but with special attention to the stakeholders and decision-makers. A new professionalism, where people with knowledge and credibility whose opinions are accepted and followed by others will be fundamental to achieve these objectives. A key objective is to positively involve the community in the discussions and decision making processes concerning environmental issues. Key aspects of a sustainable development policy will be the empowerment of local people, self-reliance and social justice. In this case the partnership and participation of all the actors in sustainable issues is required.

On the other hand, there are psychologically issues such as the "not in my backyard" principle, the NIMBY syndrome and the "Locally Undesirable Land Use" LULU problem. Locally Undesirable Land Use, is land that is contaminated (Hildyard 1993:214). The necessity of changing attitudes and behaviours, is not an easy task, particularly because the relationship between attitude and behaviour is not a direct relationship.

The promotion of sustainable behaviours must involve first the adoption of strategies and the creation of conditions to change behaviour. The psychological and social sciences give insights as to how this might be accomplished (Stern, Young and Druckam 1991).

The focus of this study concerns the demolition debris trail. CIRIA reported on a study exploring attitudes to demolition debris among some of the actors involved in construction (CIRIA 1995c). The actors viewed recycling as both a viable and necessary part of the demolition process.

<u>The demolition contractors views</u>

- Reclamation or recycling must fit into the confines of a site and there must be sufficient material to make the hire of a crusher economically viable.

- Acceptance of realistic demolition schedules by clients and the removal of unnecessary time penalty clauses would greatly increase the quality and quantity of recycled or reclaimed material.

- On the whole, selective demolition techniques are likely to improve the safety of demolition operations but this is not always case.

- Many demolition contractors allow a credit against the cost of a job, for recovered material. In the normal situation where competitive tenders are invited, this reduction in cost is immediately passed on to the client.

- Small contractors in urban areas favour local authority central recycling depots. This reduces transport and tipping costs and provides local construction projects, with a source of aggregate and other materials. However, it is not in the interests of local authorities to provide such facilities.

- The level of co-operation exercised by local authorities varies and influences the attitudes of demolition contractors.

In summary; demolition contractors are aware that they must adopt more sustainable practices whether from an environmentally conscious position; or from material self interest. They acknowledge that selective demolition provides a source for recycled materials and aggregates. An economic strategy where all gain from recycling, the introduction of clear Codes of Practices and significant practical and financial support from the Public Administration and local Authorities, are essential requirements to increase sustainable practices. The development of specifications for second material applications as well as an integrated construction and demolition management strategy, are also essential to overcome economic and technical constraints.

Central and Local Government view

- The Institute of Demolition Engineers feels that the attitude of government to recycling is not clear. It is therefore important for interested parties, to take on a lobbying role.

- Central government (at the time) is unlikely to interfere in the activities of commercial industry.

- Demolition contractors would like some form of incentive for improving methods, and increasing the quantity and quality of recycled aggregates e.g. capital grants towards the development of recycling plants, a redirection of purchasing policy to include recycled materials, and the development of national standards for recycled materials.

- Local authorities have a remarkable variation in opinion of recycled materials obtained from reprocessed demolition waste.

- London and the Southeast boast the greatest awareness and support for recycling, in association with other urban areas.

- Few local authorities accept recycled demolition debris and encourage its use in their projects.

- Several county councils are involved in using recycled asphalt for the repair and maintenance of roads.

Public and Local Authorities have the duty to contribute to these sustainable practices, with the improvement of recycling facilities, giving all the support to contractors who want to participate, and creating clear technical and legal conditions for the application of second materials.

<u>Architects and Consultants view</u>

- Waste equals loss of profit in an economic sense, if you waste less you can save more.

- Existing standards have been based on natural aggregate performance – new standards for recycled materials need to be produced or current standards and specifications amended to include recycled materials.

- Lack of well documented laboratory tests and field trials, means that designers often will not specify recycled materials as they are uncertain of their performances.

- Refurbishment and restoration work often involves specifying genuine old timber beams, reclaimed bricks and tiles and thus the materials demand a premium price.

- Some designers prefer homogeneity.

- Putting the environment first is an altruist act.

- Altruist can promote public relations, advertising the caring company which in turn can increase market share, especially amongst "green consumers".

- The recycling/reuse of demolition waste is a growth market area with considerable business potential.

The Architects and consultants view is increasingly in the way of sustainability and they must have sufficient technical and financial information in an environmental context, where the construction industry is moving. The publication of the BRE (Hobbs and Collins 1997) on the use of recycled aggregates is a step towards these ends. Tenders adopting sustainable practices must conserve competitiveness and encourage sound environmentally practices by the client.

For the Public Authorities there are the major difficulties in supporting or even adopting the sustainable construction agenda. The main problems are concerned with the bureaucracy process, which could be technocratic, singular, specialised and centralised (WCED 1987:9). Another difficulty is the absence of programmes and plans, which are blueprints for action. These are directly linked with a country's social capacity to develop and implement the actions. There is a need for more education, information, training and public participation. Significantly, there are major gaps in knowledge in this study area. That is a common problem for all the actors.

According to Mitchell (1997:157) effective citizen participation has various degrees of involvement. In these issues Public Administration must share the information and the power. Real decision making power could be shared in a collaborative partnership[6] but this is a sensitive position, with understandable risks, which need to be evaluated carefully. The intention is to achieve mutually compatible objectives, with resources, which may involve information, shared. The main implication of this discussion is that there is no one "best" model for partnerships[1]. Many choices exist. Partnerships can be of many different kinds and they can range from the personal or informal through to voluntary or legally binding arrangements.

An example of the degree or amount of public involvement, which is desirable and feasible, is presented by the Ontario Ministry of Natural Resources. Various degrees of participation are illustrated by four types of strategic alliances (Mitchell 1997:160). The types of strategic alliances involving partnership and participation are presented in Table 3.14.

These types of strategic alliances are described as:

- Contributory partnership involving an arrangement in which a public or private organisation has agreed to provide sponsorship or support, normally through actual funding, for some activities in which it will have little or no direct operational participation.

[1] A partnership is a mutually agreed arrangement between two or more public, private or non-governmental organisations to achieve a jointly determined goal or objective, or to implement a jointly determined activity, for the benefit of the environment and society.

- Operational partnership where the partners share the work rather than the decision-maker power.

Table 3.14 – Strategic alliances identified by the Ontario Ministry of Natural Resources

Type of strategic alliance	Purpose	Extent of power sharing
(1) Contributory	*Support sharing*: to leverage new resources or funds for program/service delivery	Government retains control, but contributors may propose or agree to the objectives of the strategic alliance
(2) Operational	*Working sharing:* to permit participants to share resources and work, and exchange information for program/service delivery	Government retains control. Participants can influence decision making through their practical involvement
(3) Consultative	*Advisory*: to obtain relevant input for developing policies and strategies, and for program/service design, delivery, evaluation and adjustment	Government retains control, ownership and risk, but is open to input from clients and stakeholders: the latter may also play a role in legitimising government decisions
(4) Collaborative	*Decision making*: to encourage joint decision taking with regard to policy development, strategic planning, and program/service design, delivery evaluation and adjustment	Power, ownership and risk are shared

Source: Mitchell (1997:160).

- Consulate partnerships are those in which the resource management agency actively seeks advice from individuals, groups and other organisations outside government.

- Collaborative partnership is the situation where the real decision-making power is shared.

The environmental managers have an important role as partnerships may be established at varying times during analysis and planning. Smith (1982:561-563), suggested that planning occurs at three levels:

1 – Normative, in which decisions are taken to determine what, ought to be done.

2 – Strategic, in which decisions are made to determine what can be done, and,

3 – Operational, in which decisions are made to determine what, will be done.

Psychology and social sciences have a significant influence on the interactivity of the actors trying to conciliate the cognitive aspects of the systems thinking decisions and the real world where things happen. These strategic alliances are fundamental to the implementation of a new strategy.

SECTION 5: THE IMPLEMENTATION OF A NEW STRATEGY

The Guidelines and Characteristics of the New Strategy

According to the European Union (EC 1996b) there are various issues that National Authorities, should be aware of when implementing a waste management strategy. A Specific Community Strategy for Waste Management was proposed in a Communication of the Commission to the Council and to the European Parliament of 18 September 1989. It was endorsed by the Governments of the Member States in a Council Resolution of 7 May 1990 (EC 1996c:13). This strategy is developed along the following lines:

1 - Prevention of the creation and of the harmfulness of waste. Prevention may take, for example, the form of the reuse of products and development of cleaner technologies.

2 – Promotion of different forms of recovery, including recycling and energy recovery.

3 – Minimisation and optimisation of final disposal (incineration and landfilling).

4 – Minimisation and control of waste transport.

5 – Remedial actions such as clean up of contaminated sites.

In order to correctly implement a waste management strategy, national authorities should be aware at least of the following aspects contained in national legislation on waste:

- Waste management priorities.

- Responsibilities for waste management.

- Minimum environmental standards for waste collection and transport, handling, treatment and disposal.

- Health and safety regulations.

- Fees, taxes and subsidies on waste and resources.

- Possibilities for organisation and financing.

Furthermore, a complete set of instructions for householders, commerce, industries, public authorities, in connection with proper handling of waste, for example delivery of waste in the correct containers, collection schemes, and transportation are an essential part of a waste management plan. These issues should be addressed in national legislation on waste in connection with all those involved, and should be an essential part of a waste management Strategy Plan. The process of developing the plan should involve a methodological approach linking System Thinking with "real world" activity.

The process of conceiving and comparing models and applying them to the real world is considered in Chapter 6. This discussion will focus on soft systems methodologies and systems dynamics. It will explore the appropriateness of the methodologies to deal with the realities in a quantitative and qualitative approach.

The European Union (EC 1998), in the "Caring for our Future" report, state that there will be further development of the existing strategy of encouraging sustainable and ecologically sound waste management. That is the management of waste so that it does not pose a threat to public health or the environment. The construction and demolition waste stream is identified as one of the most significant priorities. Five strategic guidelines are provided that focus on the waste stream (EC 1994a: Volume 6: Waste:170):

> - Prevention (minimisation). To prevent waste is undoubtedly the first guideline of European waste management strategy. To complete this waste reduction approach, bearing in mind that waste arises chiefly at two stages: firstly, when products are manufactured (industrial waste, etc.) and secondly, after used (domestic refuse, etc.), it is proposed that a dual preventive strategy be developed:

. prevention by technologies

. prevention by products

- Recycling and Reuse. This is the second guideline. Once waste has arisen, the best way of preventing or reducing any adverse impact on the environment is to reuse or recycle it: in other words, to bring it back into the economic cycle.

- Optimisation of final disposal is the third guideline of the strategy. Waste, which cannot be re-used or recycled, must be subject to energy recovery. Further, all possible treatment prior to landfilling must be looked at, with the aim of reducing the volume and potential hazard of the waste.

- Regulation of the transport of waste is the fourth guideline. A range of national and international provisions to guard against transport of hazardous waste is in force in the Commission's specific Directive.

- Remedial Action is the fifth guideline. The growth of an industrial society and inadequate waste management, or even no management at all, are two major causes of ground pollution by waste. Whether caused by abandoned or unregulated tips, or derelict industrial sites, this contamination is a threat not only to groundwater, but also to the environment in the widest sense.

The report goes on to state that there is a need to develop a new diagnosis in the waste management area. It expresses concerns over the slow progress towards achieving the new targets and goals, and states that some common principles to the new strategy need to be adopted. The key principles in Europe's common strategy for better waste management are:

“ 1 . The prevention principle: - we should limit waste production by tacking action at source.

2. The “polluter pays” principle and, by the same logic, the “producer responsibility” principle: the person or body that produced it should meet the cost of dealing with waste.

3. The precautionary principle: we should anticipate potential problems and take action to avoid them.

4. The proximity principle: waste products should be dealt with as close as possible to the source. It represents a better option for waste management especially in terms, of energy savings, transportation costs and security. This includes the “self-sufficiency” principle: the Community as a whole and Members States individually are encouraged to became self-sufficient in disposing of waste produced in the territory, rather than relaying on the export of waste. Questions of security, economy and better control and management are the principal drivers of these options.

This strategy must be applied directly to the construction and demolition waste stream.

In the building life cycle, the phases from inception or design to the deconstruction phase must be carefully studied and waste minimisation approached adopted. This must be closely linked with the European waste management strategy developed within the sustainability agenda.

CIRIA document (CIRIA 1995b) identified a seven-step strategy to address sustainable construction. They are:

- Design for environment.

This strategy must be supported in the use of cleaner technologies and by using impact assessment methodologies to evaluate these technologies. The choice of more friendly environmental materials, and the extraction of fewer raw materials with minimum energy use support the principles of eco-design. The use of assessment tools such as Life Cycle Assessment and Life Cycle Cost will assist in this development and must be seen as a priority. The health and safety of building users are a fundamental responsibility throughout the process.

2 – Construction – use of materials

The use of fewer materials, with less embodied energy, not using hazardous materials as well as extended the building life, will contribute to better resource management.

3 – Avoiding waste

The management and control of waste on site and labour training is an additional strategy leading towards sustainability.

4 - Maintenance

The adoption of efficient maintenance procedures will contribute to these global objectives as they delay or stop eventual demise of the building.

5 – Markets for waste materials

To establish markets for the reuse or for the recycling of waste materials derived from the rehabilitation and dismantling phases are essential. There is a need for appropriate material specifications, to permit their safe and legal use to assist in the development of the market. Natural Resources extraction taxes, as well as landfill levies, must be imposed to encourage reuse and recycling practices.

6 - Rehabilitation

Rehabilitation of used buildings should be a priority. When the need for new works occurs, the adoption of appropriate systems of collection and segregation of waste materials to enable the reuse and recycling of the material, must be the objective.

A model proposed by a European Union working group (Morgan and Argus 1995) if adopted, would this strategy to be implemented. The report illustrates the construction and demolition waste stream in a flow chart. It considered the waste stream in three phases, the preventive phase, the separation phase, and finally thetreatment phase. A market element is present in all the phases. This permits the products and materials to be fed into the market in each phase linking the model to economic constraints. This is necessary for the successful implementation of the strategy. Economic viability must be at the core of a construction and demolition waste strategy.

SUMMARY

In summary this Chapter presents an overview of the construction industry sector and its links with the environment, and a strategy towards sustainable construction. The growth of world output, the European scenario as well as the characteristics of the Portuguese construction industry are also discussed. These characteristics are considered in the context of the industry's interaction with the environment, and its role in moving towards achieving the sustainable agenda objectives. There is focus on the need to develop new cultures and different attitudes, by all the actors in order to progress to sustainable construction solutions. There is a need to minimise the consumption of raw materials and energy. The challenge to find sustainable pathways to the future, and the importance and role of stakeholders and decision-makers are also highlighted in this discussion. The importance of the social and psychology sciences in assisting this development is also noted. The importance of the involvement of all the actors' participation in the decision making process is discussed. This involvement is essential, if new attitudes and behaviours necessary for action towards a new sustainable approach by the construction industry are to be implemented.

CHAPTER 4:

SUSTAINABLE CONSTRUCTION

" The true basis for more serious study of the art of architecture lies with those indigenous humble buildings that are to architecture what folklore is to literature, or folksong to music... "

(Frank Lloyd Wright, Architect 1930)

INTRODUCTION

This chapter focuses on the concept of sustainable construction. It begins with a consideration of the dynamic of obsolescence in buildings and moves on to a discussion of environmental impact assessment as applied to waste issues. That discussion is followed by a discussion on energy, embodied energy and entropy. These concepts are then applied to the assessment of sustainability in construction. This discussion includes the issues of life cycle assessment as a tool in managing the building cycle. The final sections of this chapter address implementing the sustainability agenda and includes discussion on the role of cleaner technologies and issues of safety, quality and environmental impacts in the context of the construction industry.

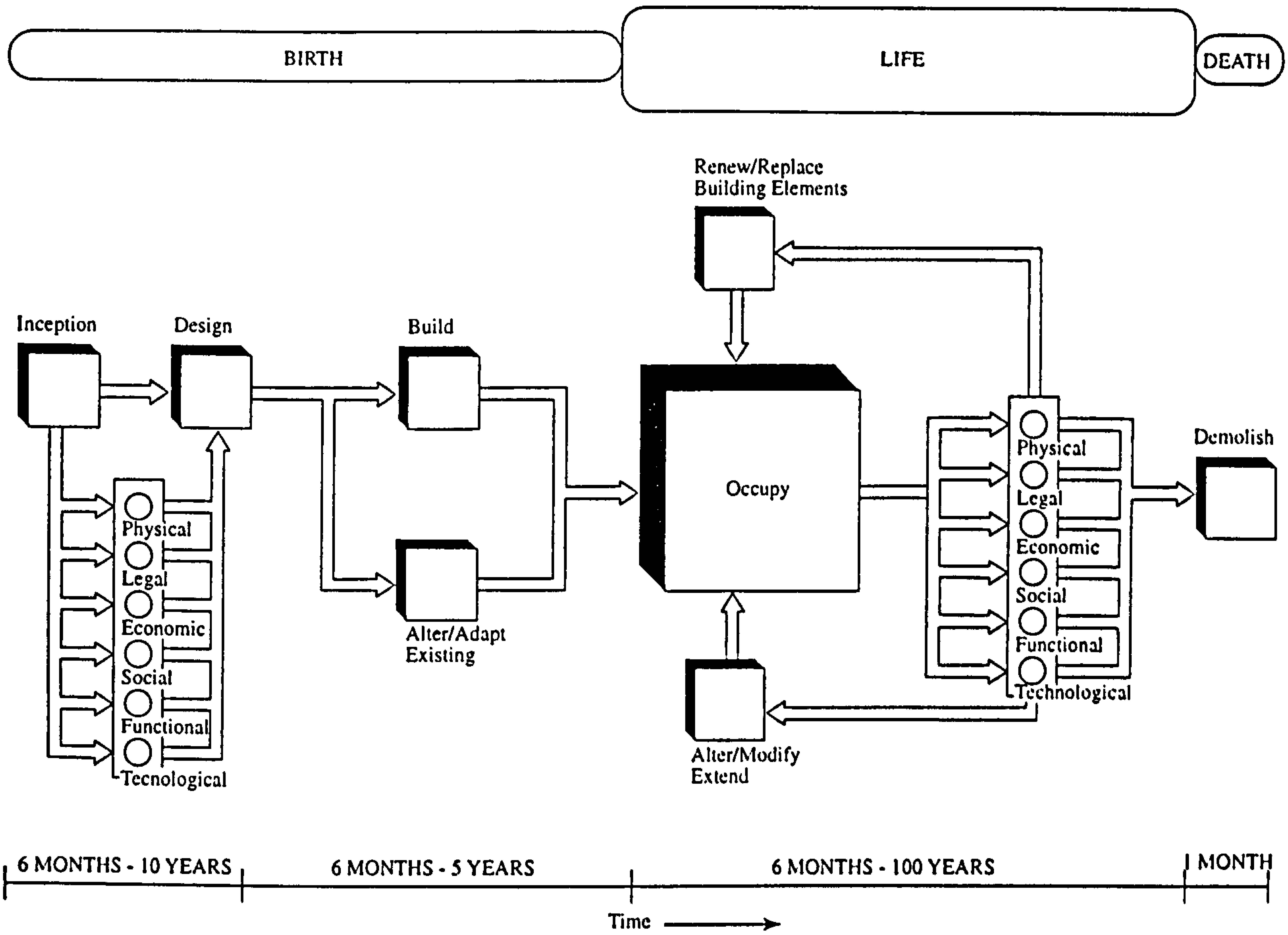
SECTION 1: BUILDING LIFE CYCLES

A building naturally moves from inception to deconstruction. This movement, the development of obsolescence, is free flowing and is interrupted by periods of rehabilitation and reconstruction and sometimes by external events that reduce the level of obsolescence Golton (1995b). The Oxford Dictionary gives us a definition of obsolescence as "becoming obsolete" and for obsolete "disused, discarded, antiquated" (Oxford Dictionary 1995). In this context, obsolescence is the degree to which a building is unsuitable for it purposes. Giving emphasis on the necessity for more precision in the use of the word Golton suggests development of the usefulness concept and refers to Nutt (1976) who defined a building as obsolete when it was unable to support any use to which it may be put.

Golton (1989) examines building obsolescence as a measure of usefulness, by adopting taxonomy based on the issues, which determine this view of usefulness. The study is a contribution to understanding these issues and their complex relationship with the strength and patterns of the driving forces. According to Golton (1995b) "Reconstruction, is a response to obsolescence which is followed by a period of use and the sequence is repeated throughout the buildings life until deconstruction becomes the response to obsolescence."

This study complements the work of other authors, for example Flanagan and Norman (1983), who seek to clarify the determinants of obsolescence. Flanagan et al. (1989) posited a sequence of a building life cycle for an owner-occupier in Figure 4.1.

Figure 4.1 – Building life cycle



Source: Flanagan et al. 1989:18 Fig. 2.5.

Flanagan and Norman (1983) defines obsolescence as the value decline that is not caused directly by use or passage of time, but they stressed that a distinction should be drawn between obsolescence and deterioration. From their point of view, an economic perspective, this is very import and their consideration, is directly related to depreciation, which is a consequence of both situations.

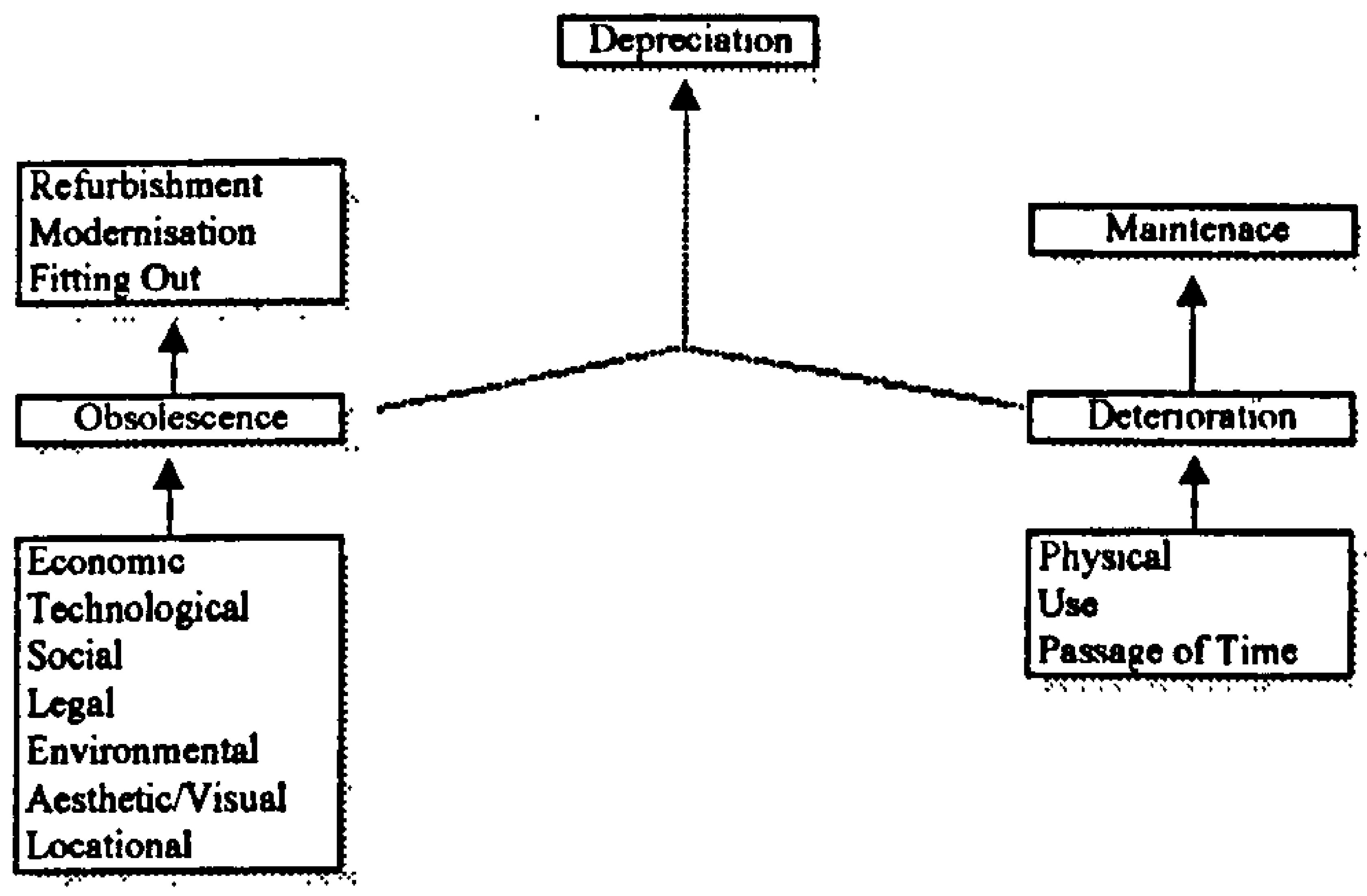
The building life cycle is difficult to forecast as obsolescence could occur due to a number of reasons such as, physical, economic, functional, technological, social and legal ones. For the period of time over which occupation is considered, the economic life of a building is considered to be the least cost alternative that meets a particular objective. A life cycle cost analysis is a significant tool in making that decision.

The RICS (1986) defined the life cycle cost of an asset as; "...present value of the total cost of that asset over its operation life, including initial capital cost, occupation costs, operational costs, and the cost or benefit of the eventual disposal of the asset at the end of its life. Life cycle cost techniques take into account, the design and management of construction projects and the total costs that the project will impose upon the client during the whole of its life." The life cycle costs analysis determines when a building becomes economically obsolete.

Technological obsolescence occurs when the building or component is no longer technologically superior to alternatives and replacement is undertaken because of lower operating costs or greater efficiency. Social and legal obsolescence occurs when human desires dictate replacement for non-economic reasons, for example some aspects of safety (RICS 1986).

Physical deterioration of a building or of its components, is a function of its use and time and significantly the quality of the materials and detailing of components and the level and quality of maintenance. This leads to the concept of depreciation. Depreciation is the economic response to deterioration and obsolescence. Figure 4.2 represents the relationships between these concepts to assist understanding.

Figure 4.2 – Depreciation, deterioration, obsolescence and their relationship



Source. Flanagan and Norman 1983: 45 Fig. 2.5.

In order to discuss the concepts of design for sustainable construction an overview of an historical perspective is useful. The idea is not new. For millennia, most buildings were intuitively sustainable. In recent times, with the development of technology and cheap energy that architecture lost its direction and departed from a synergy with nature. A building designed in empathy with its surroundings will naturally be more energy efficient and will make elegant and frugal use of local materials (Barnett and Browning 1995:14).

These observations underlie the necessity to consider the life cycle process of a building from design to deconstruction in the context of the environmental effects and impacts.

Sustainable Building Life Cycles

The concepts of sustainable construction will meet resistance. This resistance is a common thread running through the history of ideas. "...but the principles underlying the green building movement are sound. Sustainable architecture is destined to grow. In time, it will be common practice." (Barnett and Browning 1995:95). The French architect Dillenseger (1986) developed this theme when he stated that we now need to reduce a building's reliance on fossil fuel-derived high-grade energy and yet still provide for better health, comfort and security for the users.

Social, environmental, economic and also cultural issues have a significant role in the concept of sustainability in the context of construction. The most significant shift in thinking is to consider the building as a whole (Thomas 1996). An example of practical sustainable construction action in Portugal is in the National Natural Montesinho Park on the northern border of the country. The population in this area had been advised to introduce some solutions to problems that avoided energy losses, and made improvements using natural materials and traditional techniques that were in sympathy with and preserved their heritage (Guerra 1994). The involvement and participation of the public guaranteed the acceptance and adoption of the solutions.

Waste Prevention in Building Life Cycles

The role of stakeholders and the decision-makers are significant in solid waste management generally and especially in the context of waste minimisation within the management of the construction and demolition waste stream. Recognising this the

USEPA published an important two volume guide with the title "Decision-Makers Guide to Solid Waste Management" (USEPA 1989a) and (USEPA 1989b). The term "waste minimisation" occurs several times. The USEPA uses the term "pollution prevention" to refer to the same concept of waste minimisation when applied to all releases of substances into the air, land and water. USA support for the implementation of waste minimisation programmes, is contained in the Comprehensive Environmental Response, Compensation and Liabilities Act (CERCLA or "Superfund") (Hanlon and Fromm 1990). It is a significant contribution to the reduction of environmental pollution. Financial aid is available to industry under this act for waste minimisation programmes. These programmes need to match the goals and policies for waste minimisation set by national policies and reflect the organisation's management strategy (Freemen and Lounsbury 1990:72).

Waste prevention and waste minimisation are the first priorities in the European Strategy for waste management. This was expressed in the conclusions of the Expert Seminar on Waste Management Planning (EC 1994b). The conclusions reached at the seminar paid full regard to the principle of subsidiarity and can be implemented without infringing it. The seventeen conclusions were grouped into four broad areas of activity classified as: Preparing the waste plan; social acceptance; co-operation; and implementing plans and support from the Commission. Work by Vogel (1997:45) has developed the ideas on strategies for waste reduction using economic instruments. He argues that waste avoidance and waste reduction have to take into account the economic process and also environmental policy. In his work Vogel (1997) observes that the instruments of waste prevention and waste reduction can be classified as follows:

1 – Voluntary co-operative instruments. These need a strong motivation in all concerned and very often need to backed up by other measures such as monetary or other inducements.

2 – Economic instruments. These have proved to be most effective.

3 – Legislative (budgetary) instruments. These have to be introduced if voluntary arrangements between the government and the economy do not work sufficiently well.

4 – Information and education. Development of awareness of the issues is of special importance as it is central to the success of all the approaches.

A CIRIA project on waste minimisation and recycling focused on advantages of waste reduction, reuse and recycling and provides practical guidance on construction and demolition. Three handbooks have been published as a result of this work (Gutherie 1997).

- The site handbook. This book is intended for site workers and managers on both construction and demolition sites. It acknowledges the key role that contracts play in construction waste minimisation, covering issues such as, the storage of raw materials, returning packaging, substitution of raw with recycled materials, the segregation of waste on site and other similar issues.

- The designer's handbook. Design waste is defined as the waste arising from construction by acts and omissions of the designer. This includes lost opportunities to reduce waste by, for example, not using reclaimed materials. Designers have a key role to play in minimising waste from construction.

- The boardroom handbook. Waste minimisation practices should be applied at all stages of construction process, in the formulation of project proposals in the design office and on site. This handbook is addressed to policy makers in the clients boardroom and those at policy making level with the designers, constructors and suppliers.

A recent work from Woods (1998) entitled "Waste minimisation: where is it going?" emphasises the cost of waste and the benefits of implementing waste minimisation policy. This work evaluated the state of the art of waste minimisation in industry. It highlights the cost of waste in production and manufacturing processes. It follows through demonstration the financial economies that result from implementing waste prevention and minimisation policies.

The Organisation of Economic, Co-operation and Development (OECD), has also demonstrated its concern to prioritise the implementation of waste reduction policies with a special seminar held in Washington, USA in 1996 (OECD 1996a). This seminar under the theme "Waste Minimisation" brought together experts from the OECD countries in a debate on the state of the art of some priority waste streams. The construction and demolition waste stream was not appreciated (OECD 1996a). Some countries such as Australia, Japan, Canada and USA have been developing Prevention Programmes and Practical Guides emphasising the construction and demolition waste stream.

One example is the guide "A Pollution Prevention Guide for Building Construction and Demolition" and the "Pollution Prevention Program" from the Department of Natural Resources and Environmental Control, in the USA (DNREC 1996). This programme is a non-regulatory programme. It provides information about waste reduction strategies and opportunities to the construction industry. This information includes helping locate markets for some types of construction and demolition waste. The partners in this programme are the American Institute of Constructors, the National Association of Home Builders and the National Association of Demolition Contractors. The pollution prevention guide, is one of a series of guides for a range of businesses, including construction and demolition companies, and provides information on pollution control by reducing wastes and consequential costs (Vasuki 1994:3).

The levels of activity addressing the issues of waste management demonstrate the importance now being given to waste issues by both government and industry. It is also apparent that many observers and practitioners have common positions.

SECTION 2: ENVIRONMENTAL IMPACT ASSESSMENT (EIA), WASTE AND ENVIRONMENT AUDIT AND RISK ASSESSMENT

Introduction

This Section discusses environmental impact of human activities and its assessment. The discussion focuses on waste issues. It considers audit schemes to monitor and evaluate waste production together with the associated hazards and risks. The responses to safeguard against those hazards are also studied.

Environmental Impact Assessment

The word "environment" has a broad sense and it embraces the conditions or influences under which any individual or thing exists, lives or develops. These surroundings can be placed according to Gilpin (1995) into three main categories:

- The combination of physical conditions that affect and influence the growth and development of an individual or community.

- The social and cultural conditions that affect the nature of an individual or community.

- The surroundings of an inanimate object of intrinsic social value.

The human environment includes the abiotic factors of land, water, atmosphere, climate, sound, odours and tastes, the biotic factors and the social factors. The common biotic factors for humans are fauna, flora, ecology, bacteria and viruses. The social factors are the factors, which make up the community's quality of life. The European Council Directive 85/337/ EEC of 27 June 1985 (EC 1985), has defined "environment" as the combination of elements whose complex interrelationships make up the settings, the surroundings and conditions of life of the individual and of society, as they are or as they are felt. In the context of environmental impact, "impact" means the effect of one thing upon another. In this context, Environmental Impact Assessment (EIA) is the official appraisal of the predicted effects of a proposed policy, program, or project on the environment. It addresses the alternative measure that can be adopted to protect the environment.

The European Union requires an EIA for most major projects and proposals. The European Council EIA Directive 85/337/EEC applies the term "Environmental Impact Assessment" to the identification, description, and assessment of the direct and indirect effects of a project. The effects concern human beings, fauna and flora; soil, water, air, climate and the landscape. They concern the interaction of these factors and the effect on material assets, and the cultural heritage. The US National Environmental Policy Act (NEPA) has incorporated a requirement for assessing the environmental impact of "major federal actions significantly affecting the quality of the human environment". Many other countries such as the UK, the Federal Republic of Germany, Denmark and some other Nordic countries (Gilpin 1995) have adopted this concept.

An EIA is essential prior to developing some types of civil engineering works and buildings, this includes some types of waste, treatment and disposal facilities

(Gilpin 1995). Generally EIA has been limited to larger construction projects where its use is often compulsory (CIRIA 1995d). However some public sector authorities have voluntarily extended EIA to smaller projects. The UN Conference on Environment and Development in 1992 recommended the global application of the EIA technique. Principle 17 of the final agreement states: "Environmental Impact Assessment, as a national instrument, shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority" (UN 1992a).

Barrow identified a number of problems, challenges associated with the future of impact assessment (Barrow 1997: 293). He observed problems in implementation of EIA that included:

"– The process is often avoided.

- It is often not carefully integrated into planning.

- It fails to ensure that developments are environmentally sound.

- Cumulative impacts are not assessed adequately.

- Public participation in environmental impact assessment is often inadequate.

- A monitoring assessment is rarely conducted after the process has been completed.

- An assessment of risks and social impacts is often omitted from environment impact assessment.

- The new challenges on impact assessment identified by Barrow (1997: 293) are:

-Problems concerning the global common issues.

-Environmental impact assessment in relation to development assistance.

- Environmental impact assessment and international trade.

- Support for Sustainable Development

More recently, the ingredients required for a successful EIA were identified by (Barrow 1997:293) as:

- Satisfactory methods.

- Effective procedures.

- Supportive legislation.

- Sufficient data.

- Funds to pay for assessment.

- Clear indication of what is subject to impact assessment.

- Competent impact assessors.

- Freedom to assess effectively.

- Effective co-ordination, auditing and monitoring.

- Investigation of assessment shortcomings and means of appeal against them.

- Adequate public participation.

- Integrity of those commissioning, conducting and using impact assessment".

Environmental Management and Auditing Scheme

One of the most important instruments of the EU is the statement of participation under its voluntary Environmental Management and Auditing Scheme (EMAS) (IZT 1997). This new instrument embodies the concept of preventive environment policy and is mainly applied to companies. Companies that want to participate must assess the environment impact of their products, processes and services. The results should consist of detailed quantified targets for the reduction of impact and a programme for pollution prevention (IZT 1997). The objective of EMAS is to promote continuous improvement in the environmental performance of industry by:

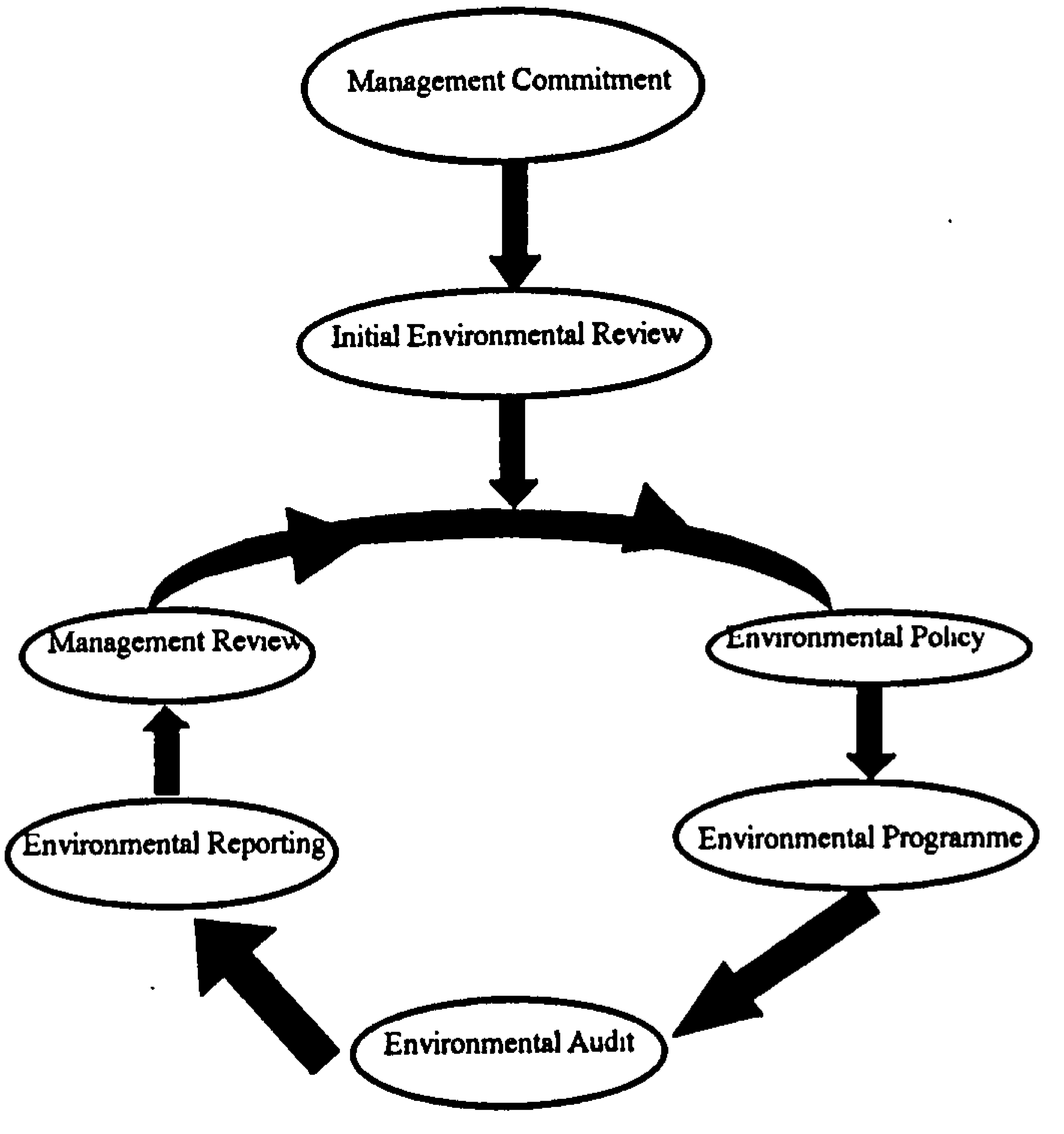
"- The establishment and implementation of environmental policies, programmes and management systems by companies, relative to their sites.

- The systematic, objective and periodic evaluation of the performance of such elements (internal audits and validation by an independent verifier).

- The provision of information to the public (statement) on environmental performance.

An implementation guide of EMAS in waste management organisation is explained in general term below. Figure 4.3 presents an overview of a schematic diagram of general Environmental Management System.

Figure 4.3 – A schematic diagram of an Environmental Management System (EMS)



Source: IWM 1998 Fig. 2: 6.

This figure is a schematic diagram of a general EMAS. It shows the stages, which should be followed by any organisation embarking on implementing such a system, and is, in general terms applicable to both ISO 14000 and EMAS. ISO 14000 was launched as the international standard for environmental management.

ISSO 14000 has been applied in some EU countries in preference to EMAS. The UK Institute of Wastes Management has observed that care is needed in the application of EMAS in waste management (IWM 1998:5). Issues of concern include:

- National and international good practice needs to be applied in all fields of environmental management, not just in waste management.

- A commitment towards improvement and prevention of pollution using the best available technology where economically viable.

- Public perception and communications with the public.

In the context of this research, environmental audit and the more significance waste audit are particularly important when dealing with hazardous wastes. It is a necessary undertaking prior to any deconstruction work. The guidelines for a waste audit for industrial waste area can be found in the Emissions and Industrial Waste Audit and Reduction Guide (ONUDI/PNUE CAP/IE 1992). These guidelines have to be adapted to the specific objectives of a building waste audit on deconstruction. The necessity of developing a waste audit before beginning the deconstruction process is stressed in the Manual de Deconstrució from the Catalunya (Junta de Resídus 1995b).

Risk Assessment

Risk is associated with hazard. A hazard is defined as a source of danger, whilst risk is the likelihood of the hazard resulting in actual loss, injury, or some form of damage (Soesilo and Wilson 1997: 213). Expressing the relationship between risk and hazard, Kaplan and Garrick (1981:11-27) symbolise the idea in form of an equation:

$$Risk = Hazard / Safeguard$$

The equation illustrates that by increasing the safeguards the risk is reduced. Hadden (1984) states that the study of risk involves not only uncertainty in assessing the frequency of occurrence but also the level of the consequent loss or damage. Estimating risk involves determining the probability of consequences (Pc) and the value of each consequence (Vc) to the risk taker. This is present as an equation:

$$Risk = f(Pc, Vc)$$

In the USA, there is significant experience in dealing with contamination situations. The 1976 Resource and Recovery Act established a system of tracking hazardous wastes from their generation through ultimate disposal. The main objective of the Act was to prevent future problems from being created by hazardous substances (Wentz 1989). The Superfund Law, or the Comprehensive Environmental Response, Compensation and Liability Act referred to earlier became law in 1980. This had the objective of closing legislative e gaps in site remediation that had not been addressed by other environmental legislation. After some up dating, it is still applied as a response for incidents involving hazardous substances. USEPA divides a human health risk assessment, or silply risk assessment into four distinct components (USEPA 1989c):

- Data collection and evaluation.

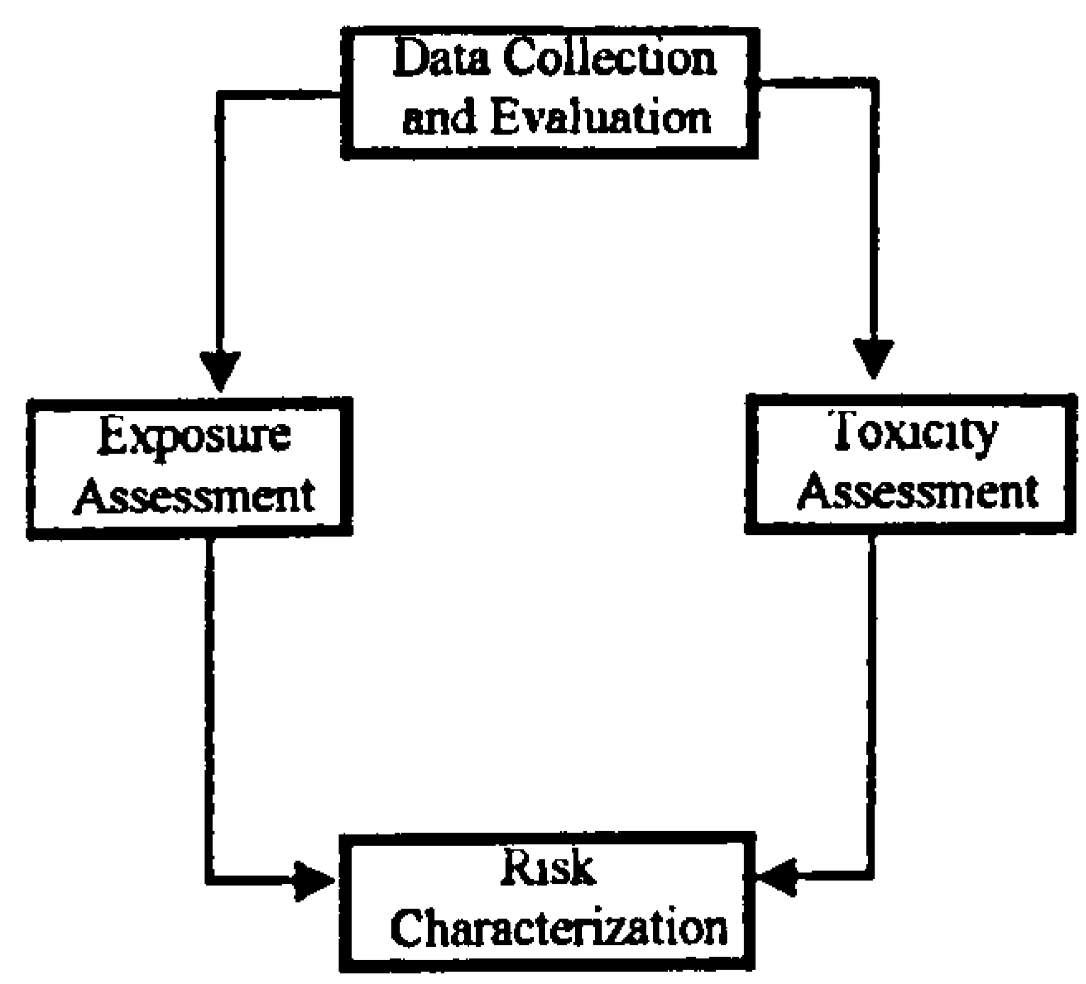
- Exposure assessment.

- Toxicity assessment.

- Risk Characterisation.

Figure 4.4 displays these components and illustrates how they relate to each other. In summary, this is a systematic process for estimating the level of risk from a hazard by evaluating the probability and level of exposure and level of toxicity.

Figure 4.4 – Human health risk assessment

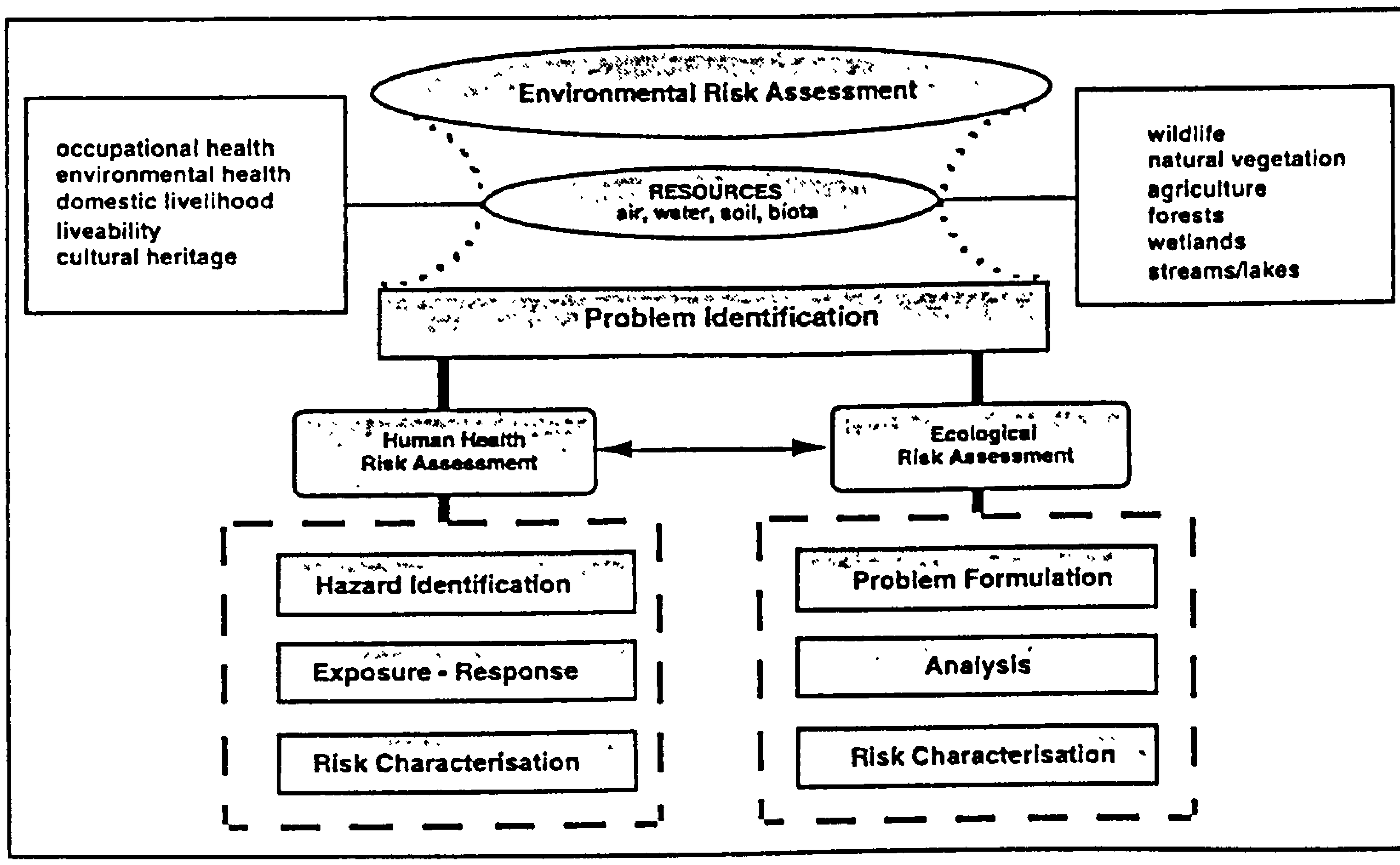


Source: USEPA 1989c Part A, Interim Final, Fig. 9.1: 25.

In site remediation, risk assessment consists of both a human health risk assessment and an ecological risk assessment normally referred to as an environmental risk assessment. CIRIA (CIRIA 1996a) refers to the use of the Hazard Source Pathway Target Receptor Model as an essential tool in this assessment. The model can be subdivided into risk assessment, risk management and risk communication. Risk assessment includes estimating the probability of harm occurring and the severity of the harm. Risk assessment according this document must be classified in qualitative risk assessment where risks are categorised in low, medium and high, and quantitative risk assessment. Quantitative risk assessment should be used when hazards are perceived to be high and damage potentially unacceptable and in high profile projects where third parties or the public are involved. Risk management involves isolation or removal of hazards, interception of the pathways by which hazards reach targets and isolation or removal of the targets.

The Sustainable Cities Programme, a joint initiative of the UN Centre for Human Settlements (UNCHS, also referred as Habitat) and the UNEP, has published a study (UNEP/ITEC 1996b) on environmental risks assessment for sustainable cities. This study also highlights the role of environmental risk assessment in the move towards sustainability. Figure 4.5 from this study illustrates the relationship between the components and the applications of the environmental risk assessment.

Figure 4.5 – Environmental Risk Assessment. Components and application



Source: UNEP/IETEC 1996b: 2.

SECTION 3: ENERGY, EMBODIED ENERGY AND IMPACTS

Introduction

This Section concerns energy, energy consumption and embodied energy in materials and buildings. Impacts from the consumption of energy and materials are also referred to in this section.

Energy

Energy consumption in building construction, use and maintenance is a significant factor and includes the embodied energy[1] in materials and components. Raw materials consumption is also significant throughout the building life cycle. The energy used in buildings from fossil fuels, produce carbon dioxide (CO^2) which has a predominant role in increasing the green house[2] effect. In the UK, for example, buildings use around 40 or 50 % of the fossil energy supplied and produce 50 % of the

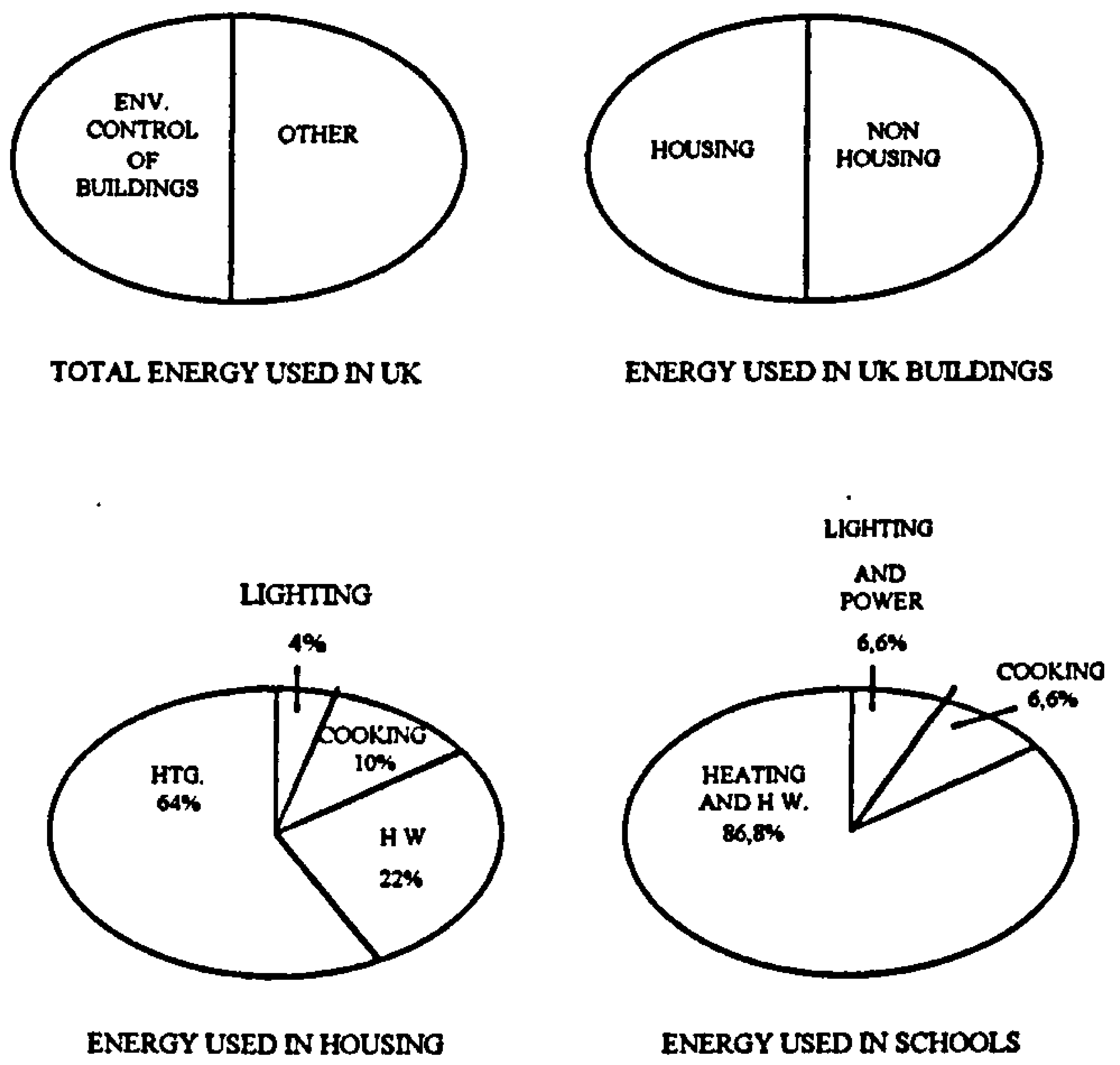
[1] Embodied energy has been defined as the energy used to win raw materials, convert them to construction materials, products or components, transport the raw materials, intermediate and final products and build them into structures (Thomas 1996:70).

[2] Green house effect warming of the trophoshere (esp.near to ground level) caused by the absorption of terrestrial radiation by greenhouse gases (especially carbon dioxide CO2) due to human activities (Oxford Dictionary 1995).

total CO^2 emission (Thomas 1996:29). In a world context, the UK is responsible for about 3% of the world CO^2 emissions.

A UK report from SCQS (1984) on Life Cycle Cost Planning, and energy economics reported that the use of energy is important in its own right for environmental and ethical reasons. Figure 4.6 shows information about the percentage of total energy used in the UK in building construction, housing and schools. It highlights the significance of energy consumption.

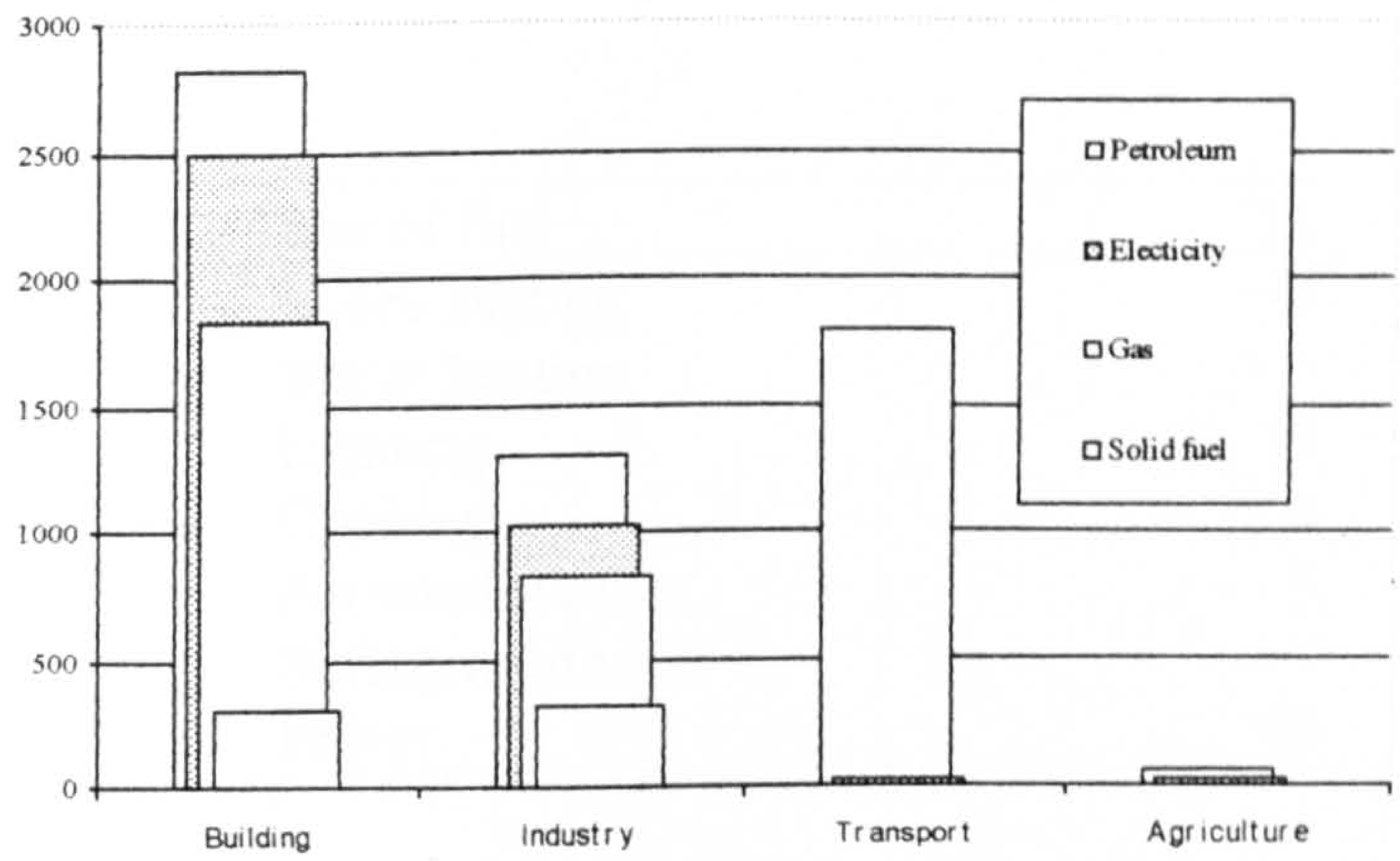
Figure 4.6 – The significance of energy consumption in UK



Source: SCQS 1984: 19.

Figure 4.7 gives information about the UK energy consumption by sector and by delivered fuel type.

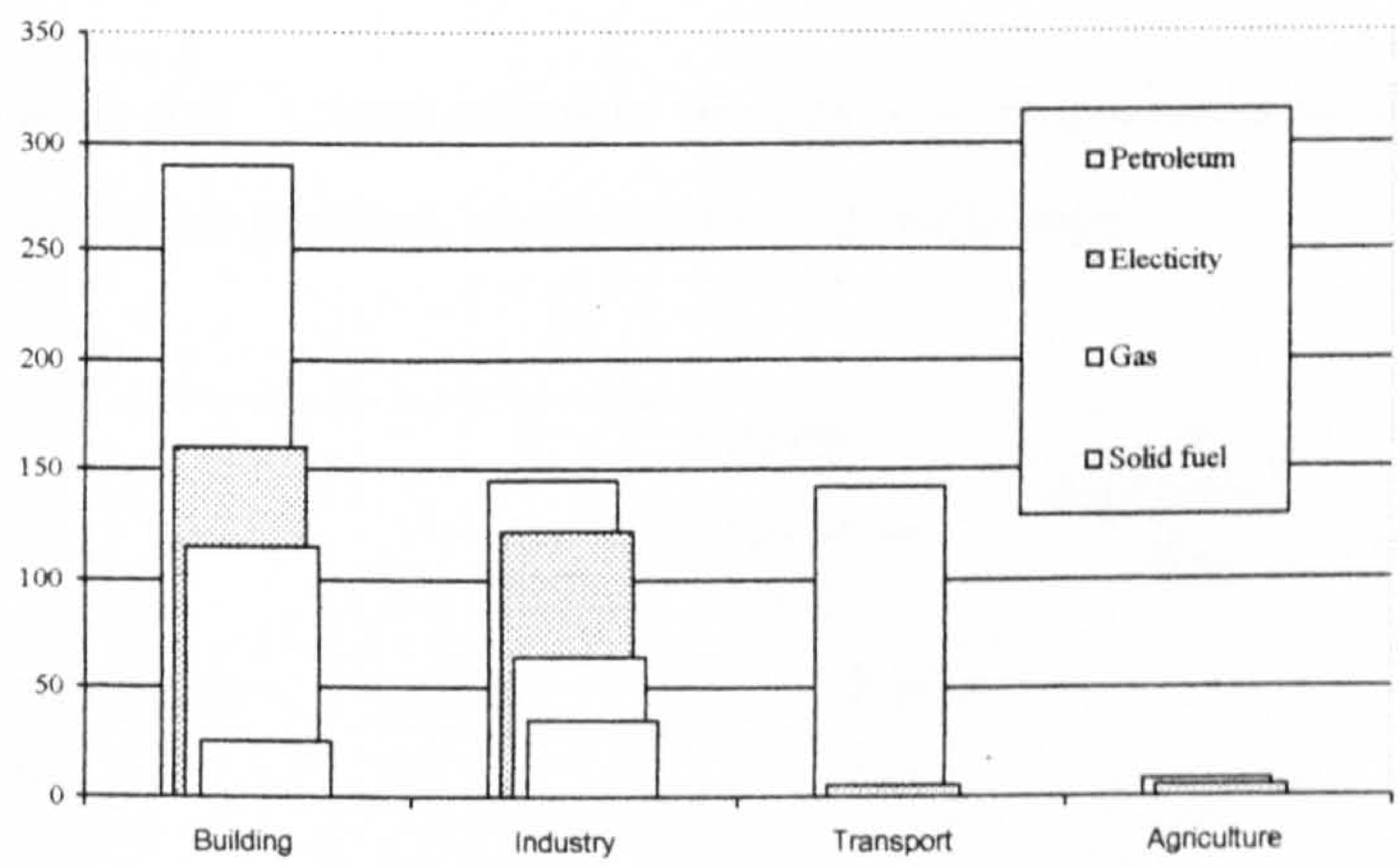
Figure 4.7 - UK delivered energy consumption by sector and by delivered fuel type



Source: Thomas 1996: 29.

The UK total service sector CO^2 emission is about 89 million tonnes and approximately 44% of this is used to heat building (Thomas 1996:30). Figure 4.8 presents the emissions by sector as well as the type of energy and by fuel type.

Figure 4.8 – UK carbon dioxide emissions by sector and by fuel type (1987)



Source: Thomas 1996: 30.

Figure 4.9 gives the information on the UK carbon dioxide emissions by end use for source sector.

Figure 4.9 – UK carbon dioxide emissions by end use for the UK service sector

Use of fuel	%
Space heating	44
Water heating	7
Lighting	17
Cooking	6
Air conditioning	6
Refrigeration	7
Power	13

Source: Thomas 1996: 30.

Heating buildings, in the UK, is necessary for the users to provide a comfortable and healthy environment. The level of energy resource used and pollution generated by building is shown in Table 4.1. It demonstrates the necessity for increased efficiency in this sector.

Table 4.1 – Approximate energy consumption and carbon dioxide production for selected activities, equipment and buildings

Item	Energy Consumption (kWh)	*CO_2 Production (Kg)*	Period	*Notes*
Man at rest	2.8		day	
Shower	1.8	0.4	5 minutes	Water heated with gas
Bath	3.3	0.7		80 litre bath heated with gas
Dishwasher	2	1.5	1 cycle	Including heating the water with electricity
Fridge/freezer	2.2	1.6	24 hours	
100-watt filament light bulb	2.4	1.8	24 hours	
Equivalent miniature fluorescent	0.5	0.4	24 hours	
For an average 3-bedroom dwelling:				
Electricity consumption	2 000	1 500	1 year	Excluding water or space heating

Water heating	2 000	420	1 year	Using gas
Space heating	22 500	4 720	1 year	Using gas
Space heating – new house target	10 000	2 100	1 year	Using gas
Domestic heat recovery ventilation system	1 750	1 300	1 year	Electricity in running the fans
For a 1500 m^2 primary school				
Electricity use	45 000	34 000	1 year	Mostly lighting
Gas use	225 000	47 000	1 year	Mostly heating
For a 1500 m^2 air-conditioned office				
Electricity use	525 000	395 000	1 year	
Gas use	420 000	88 200	1 year	
100 Km car journey	100	22	2 hours	
Acre of corn		3 000	1 year	CO_2 fixed

Source: Thomas 1996: 31.

To move towards sustainability it will be necessary to reduce energy demand. An essential tool in guiding those adjustments is the environmental assessment methodology. For it to be an appropriate methodology for building it must be applied to the full life cycle (Twidel and Weir 1994). Twidel and Weir (1994) also observe that in the long-term physical factors of energy resources, technological constraints and social norms influence the direction of society. Educational, planning, financial and industrial policy must also be adjusted to a new strategy. The overall effect will be to contribute to a society more knowledgeable and conscious of its environment and the need to move towards sustainability.

Renewable energy is energy derived from resources that are not depleted as a result. Hydropower, solar, wind, wave, tidal, ocean thermal, biomass and geothermal energy are usually included in this category (Oxford Dictionary 1995). Another definition of renewable energy is energy from sources that do not depend on the extraction of fossil or fissile resources, but on naturally occurring energy flows (Slesser 1988: 238). Green energy or more properly biofuel[3] could replace the fossil fuels in use

[3] Bio-fuel such as methane, or liquid fuel, such as ethanol, made from organic waste material, usually by microbial action (Oxford Dictionary 1995).

today, coal, oil and gas. These are the energy sources of the post industrial revolution society, or "modern civilisation" (UNESCO/UNEP 1991).

Embodied Energy

This Section focuses on the initial energy or embodied energy in building materials and components and on the production process itself. It also considers the carbon dioxide (CO^2) emissions to the atmosphere.

Initial energy or more properly embodied energy, has been defined as the energy, used to:

- Win raw materials.

- Convert them to construction materials, products or components

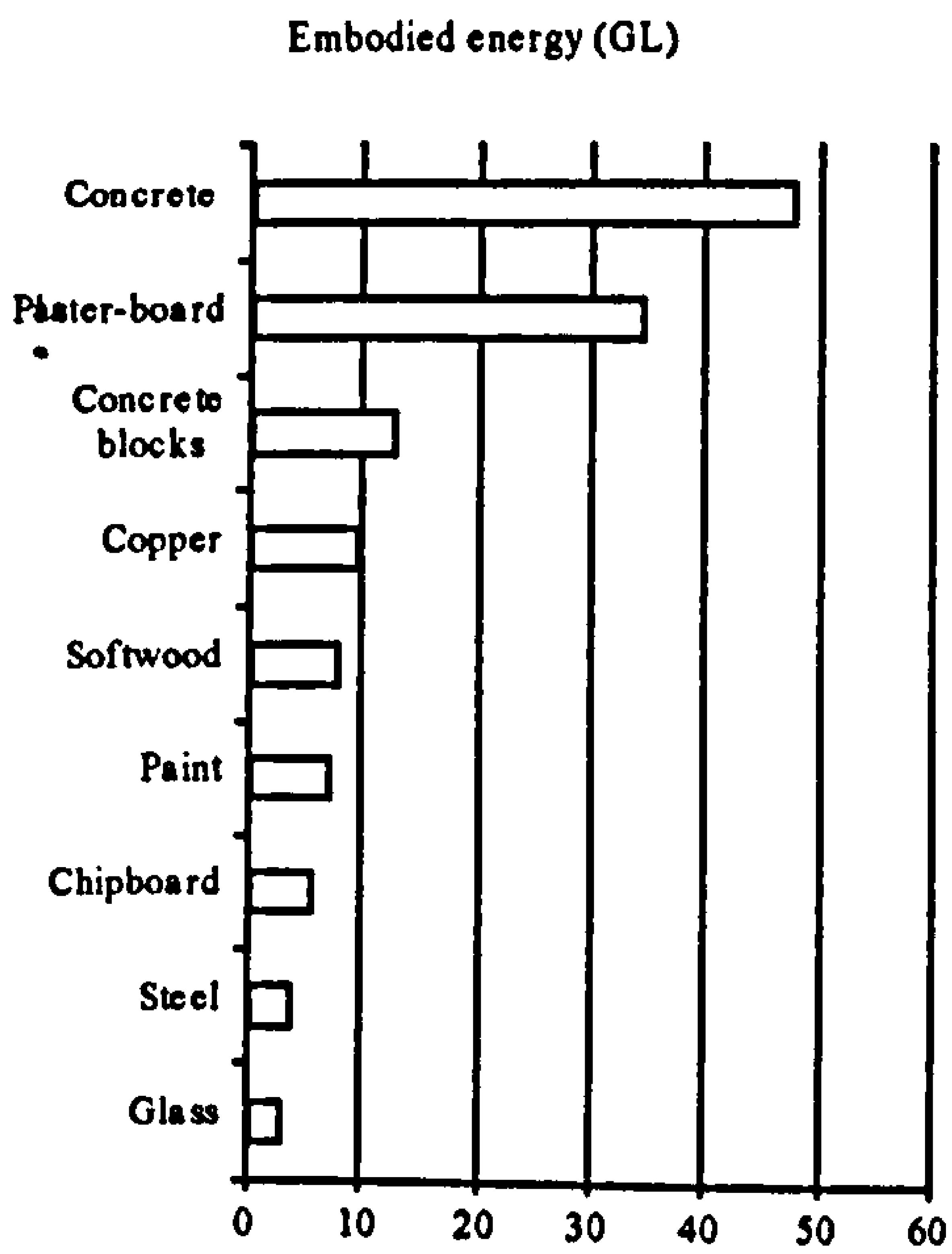
- Transport the raw materials, intermediate and final products.

- Build them into structures (Thomas 1996:70)

These issues should be carefully weighed in developing a design solution.

The concern, to reduce energy consumption and pollution must be present from conception. This involves the assessment of the consumption of raw materials their future utilisation and the energy and pollution trails associated with that utilisation. It is necessary to include in the assessment not only the building envelope, the "skin", but also all item that are related to the internal layout, from the site planning, to energy sources, lighting, comfort and infrastructures with the objective of lowering energy consumption (Thomas 1996). 5% to 10% of the embodied energy in buildings is encapsulated in the services systems (Thomas 1996:72). Figure 4.10 shows the approximate embodied energy inputs for an UK typical detached house (Thomas 1996:72).

Figure 4.10 – Approximate embodied energy inputs for a brick detached house



Source: Thomas 1996: 72.

In contrast the embodied energy of an office building is approximately 3.5 to 7.5 Gj (Giga joules) per square metre and the in use consumption is approximately 0.5 to 2.2 Gj/m^2/yr. (Thomas 1996). Together initial energy and running energy are known as utilised energy. The total embodied energy in an office is equivalent to the energy utilised during 5 years life, or about 7% of the total energy consumption for a building lasting about 70 years (Thomas 1996). It demonstrates that embodied energy is of significant weight in the global context of energy consumption. This is especially true as the life of buildings is rapidly decreasing, increasing the significance of the embodied energy. Embodied energy has been the subject of study in the UK and Table

4.2 shows the output of that work and gives a broad comparison of the energy requirements of building materials.

The information must be used with care as the level of confidence in it is low as the figures are greatly affected by issues such as the type of fuel utilised in winning and processing the material. Major influences are also the location, travel distances and means of transporting the materials from source. A study of a specific house demonstrates these issues (Gartner and Smith 1976) and shows the accumulation of embodied energy within several components into the global figure for the embodied energy of the building. The principal materials that constitute buildings are included in this study but glazing, finishes, and services were excluded in this study.

Table 4.2 – Broad comparative energy requirements of building materials

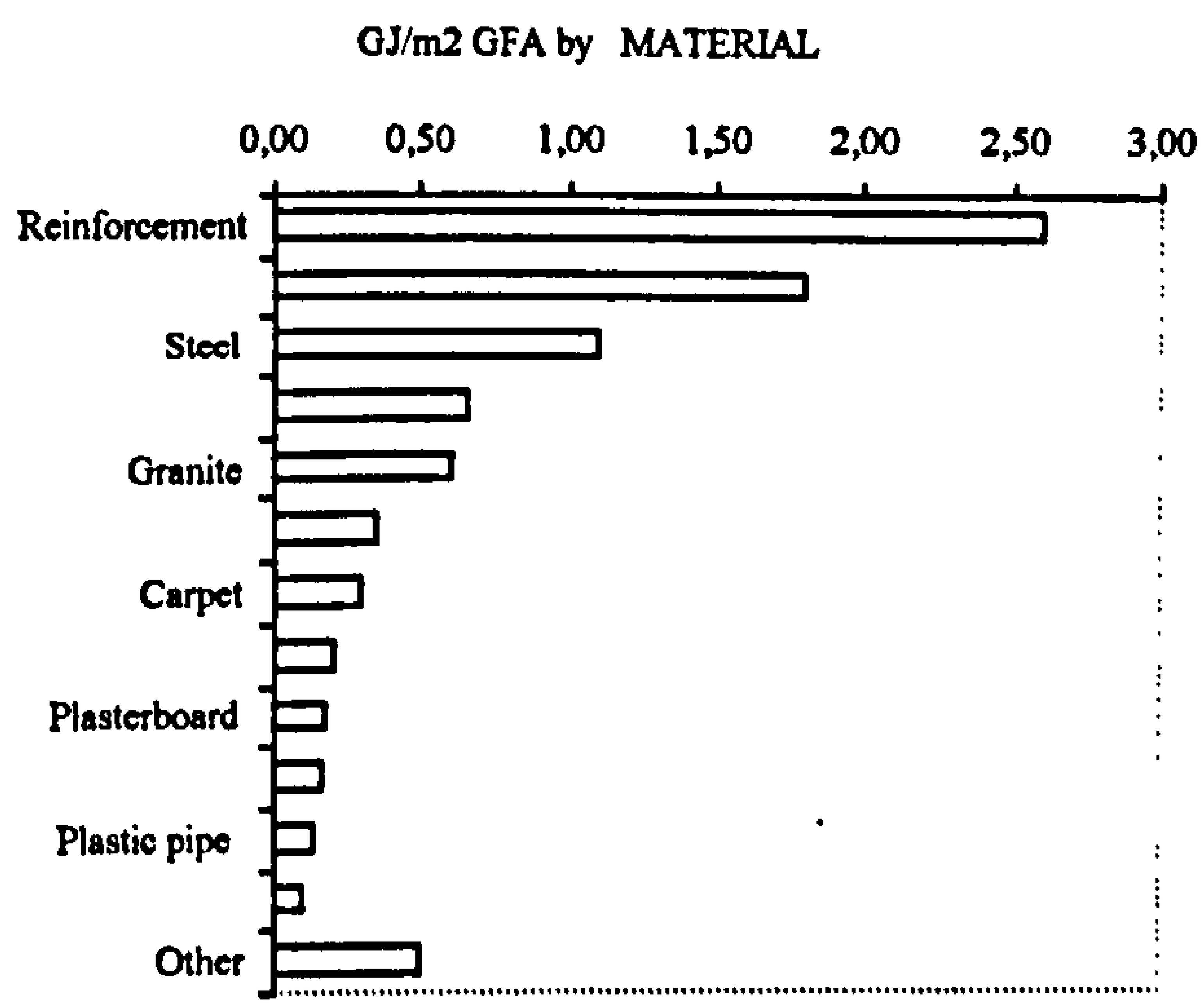
	Primary energy requirement (GJ/tonne)		
Material	Worldwide	UK	UK
Very-high-energy			
Aluminium	200-250		97
Plastics	50-100		162
Copper	100 +		54
Stainless steel	100 +	75[a]	
High-energy			
Steel	30-60	50	48
Lead, zinc	25 +		
Glass	12-25		33
Cement	5-8		8
Plasterboard	8-10		3
Medium-energy			
Lime	3-5		
Clay bricks and tiles	2-7	2	3
Gypsum plaster	1-4		
Concrete:			
In situ	0.8-1.5		1.2
Blocks	0.8-3.5		
Precast	1.5-8		
Sand-lime bricks	0.8-1.2		
Timber	0.1-5		0.7[b]
Low-energy			
Sand, aggregate	< 0.5		
Flyash, volcanic ash	< 0.5		
Soil	<0.5		

Source: Thomas 1996: 70.

The knowledge of energy requirements of building materials has become very important in the design phase. The designer needs to choose technical solutions of building construction. The solutions must optimise energy consumption by assessing the levels of embodied energy embodied, the length of life of the components and the in use energy consumption. The figures will be conditioned by the efficiency with which the materials and components can be reuse or recycled. These concerns will influence the choice of materials.

Tucker and Treloar (1994), point out that the construction sector receives a high proportion of embodied energy in material inputs compared to the direct energy demand. The same study presents the embodied energy per m^2 of the gross floor area by material group and element respectively (see Figure 4.11).

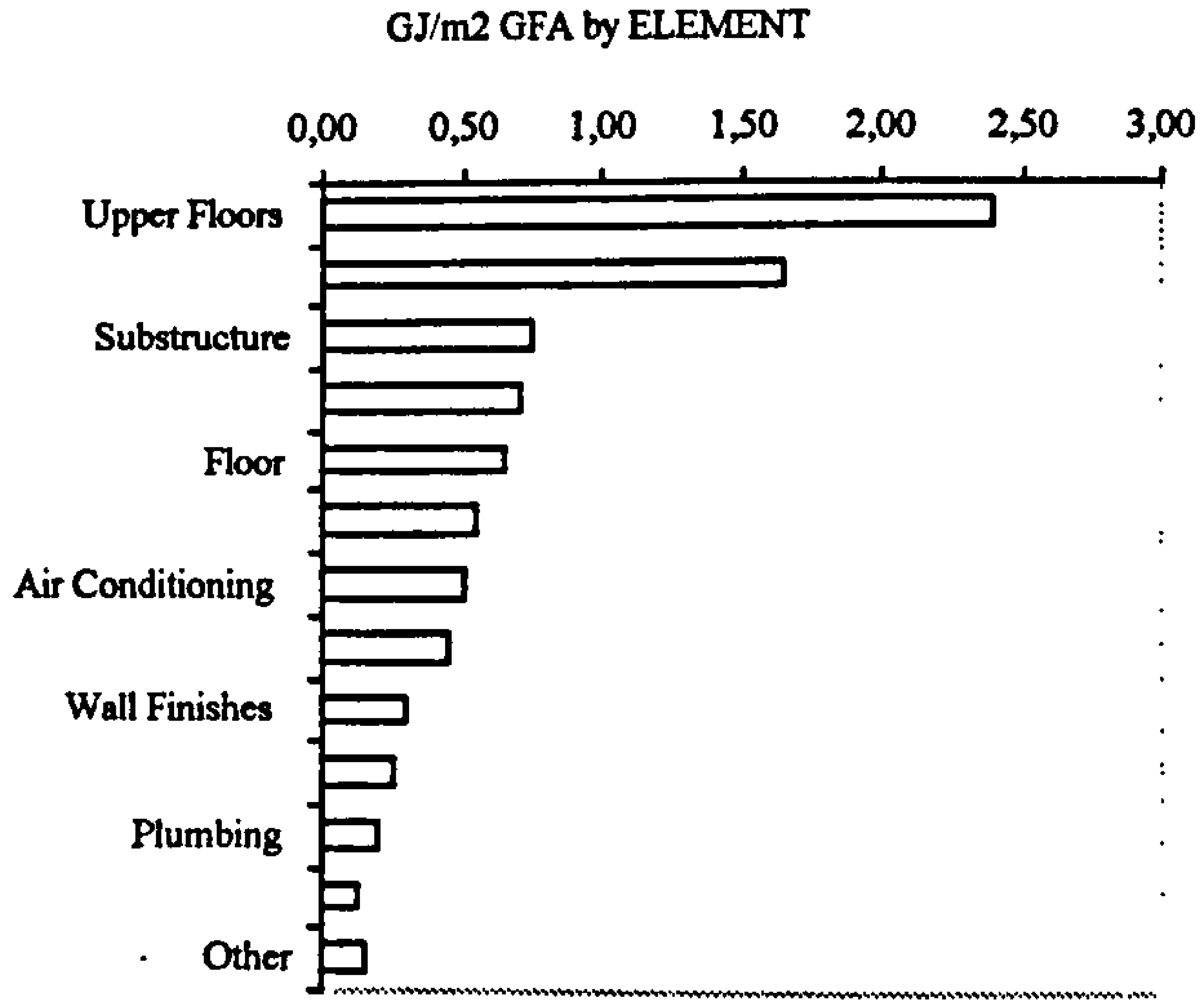
Figure 4.11 – Embodied energy per m2 of gross floor area by material – new construction case study



Source: Tucker and Treloar 1994, Session: Materials, Paper 1:5.

They also observe that the CO^2 emissions due to fossil fuel consumption are proportional to the embodied energy breakdown by element (see Figure 4.12). The average CO^2 emissions per unit of embodied energy for all materials in the building case study were approximately the same as the average across the construction sectors which is 97.5 kg/GJ.

Figure 4.12 – Embodied energy per m2 of Gross Floor Area by element – new construction case study



Source: Tucker and Treloar 1994, Session: Materials, Paper 1:5.

Impacts

The building sector produces significant impacts on the environmental due to the quantity of resources consumed to manufacturer components and materials. This also includes the area of land that is taken into the built environment. As the building is used, maintained, repaired and renovated wastes are produced. These create, according to Anink, Boonstra and Mak (1998), the following ecological load:

- 50 % of material resources taken from nature are building related.

- Over 50 % of national (Netherlands) waste production come from building sector.

- 40 % of the energy consumption in Europe is building related.

These figures are a near match to those reported by other observers. There is a need to measure those impacts of construction.

SECTION 4 : ASSESSING SUSTAINABILITY IN CONSTRUCTION

Introduction

Scientific studies of waste started in the UK in 1963 with the objective of establishing the overall incidence of waste (Skoyles and Skoyles 1987:14). The focus has widened to other areas such as minimising the construction and demolition waste stream. As Skoyles and Skoyles (1987:149) observe, in construction industry sector waste materials represent lost profits. Some tools have been developed that can assist in the characterisation, estimating and assessment of the waste stream.

The Building Research Establishment Environmental Assessment Method (BREEAM) from the BRE (UK) is an important approach. This is a scheme for the environmental labelling of buildings. The concept was to follow a set of common issues under three main headings. This gives clarity and aims for a broad and balanced approach to environmental assessment. The issues were grouped as follows (Yates, Bartlett and Baldwin 1994:1):

- Global issues and use of resources. These issues are related to the production of carbon dioxide resulting from energy consumption. This group also includes issues of ozone depletion due to the release of CFCs, HFCs and Halons.

- Local issues. These issues are related to noise, pollution of the microclimate, water economy and legionnaire's disease arising from wet cooling systems.

- Indoor issues. These issues are related to ventilation, passive smoking and humidity, lighting, thermal comfort and overheating.

The output of the scheme is a certificate awarded to individual buildings stating clearly, and in a way that can be made visible to clients and users alike, the performance of the building against a set of defined environmental criteria. The certificate can be displayed in the building, or used in a promotional portfolio. It may form part of the developer and occupier's overall environmental policy statement and management system.

The issues covered under BREEAM cover environmental criteria, and provide a practical way of assessing buildings from a sustainability perspective. It has been criticised for adopting an apparently random set of criteria. Whilst there is some basis for that criticism, the method pioneered environmental quality assessment in building. The issues covered under BREEAM are summarised in Table 4.3 below.

Table 4.3 – Common issues in BREEAM

Global Issues and Resources	CO2 emissions resulting from energy use
	Acid rain
	Ozone depletion due to CFC's (chlorofluorocarbons), HCFCs (hydrofluorochlorocarbone)
	Natural resources and recycled materials.
	Storage of recycled materials
	Designing for longevity
Local Issues	Transport and cyclists' facilities.
	Water economy.
	Noise
	Local wind effects
	Overshadowing of other buildings and land
	Contaminated land
	Ecological value of the site
Indoor Issues	Hazards materials.
	Natural lighting.
	Artificial lighting.
	Thermal comfort and overheating.

Source: Yates, Bartlett and Baldwin 1994:3.

In this assessment method, the performance of the building, with respect to the criteria, can be expressed at one of four levels, Fair, Good, Very Good and Excellent. This criteria is based on a minimum level of credits achieved in each of the three sections (global and resources, local and indoor issues). The methodology to measure and label the environmental impact of buildings is enjoying considerable success in the UK (Yates, Bartlett and Baldwin 1994).

BEPAC

Another assessment criteria for the environmental performance of buildings was developed in Canada and inspired by the BREEAM programme. The Building Environmental Performance Assessment Criteria (BEPAC), launched at University of British Columbia, Vancouver, Canada in 1993, is the first comprehensive method in Canada to evaluate the environmental performance of new and existing buildings (Cole 1994:1). The method is structured in five major topics as follows:

- Ozone layer depletion. With the discovery of the ozone layer thinning in the Arctic and mid-latitudes, evidence of the damage caused by chlorofluorocarbons (CFCs) continues to grow. This leads to scientific consensus that an eighty-five percent reduction in controlled Ozone layer depletion Substances (ODSs) emissions is required to stop future depletion of the layer.

- Environmental impact of energy use. Energy use is central to addressing the environmental agenda. However, rather than being solely concerned with energy use reduction per se, BEPAC assesses the environmental impacts of using fuels.

- Indoors environmental quality. The qualities of the indoor environment, which are evaluated in BEPAC, are indoor air quality; lighting quality and acoustic control.

- Resource conservation. Reducing the environmental cost of material use in offices is an important complement to reducing the operating energy and ozone depletion impacts. This typically entails programmes to reduce consumption, to reuse and recycle and to purchase products with lower initial "environmental cost" such as those with recycled content.

- Site and transportation. The major premise of the site and transportation section is that automobile commuting is the most important environmental impact of office building location and that strong management incentives are necessary to alter the commuting habits of people.

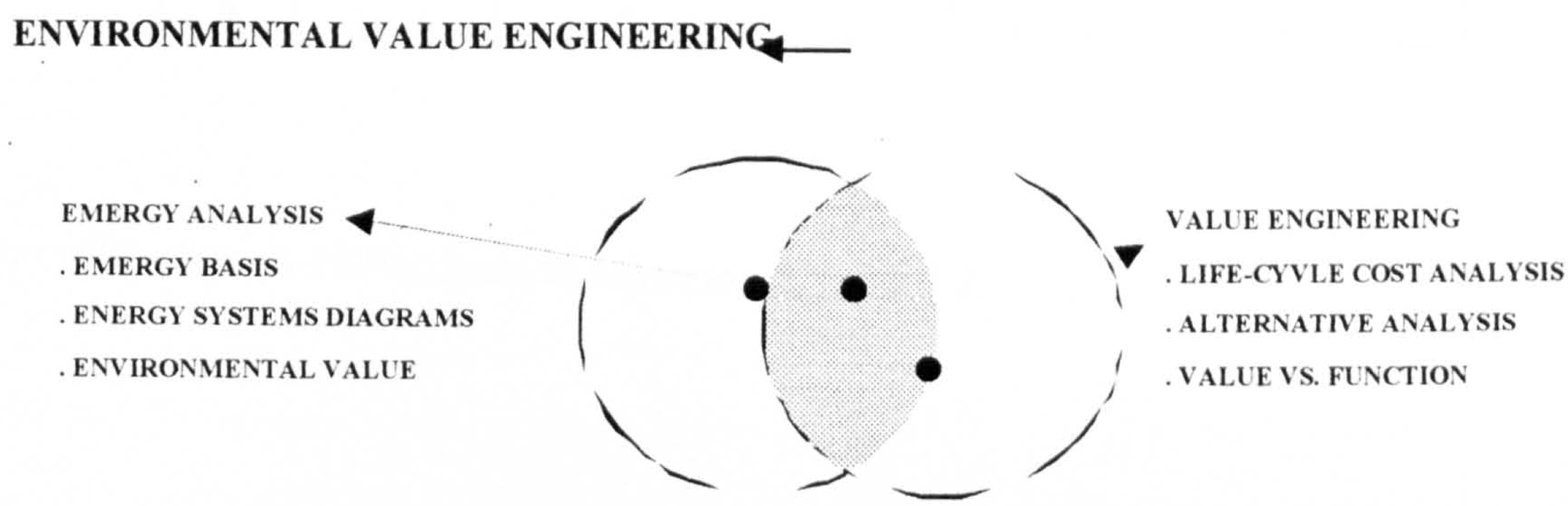
This application of this environmental assessment is voluntary environmental and offers a certificate of quality. It encourages the construction industry to introduce more environmentally satisfactory practices as well as raise performance standards.

There are other methodologies to assist in linking and prioritise green criteria. They mainly follow the lead and approach of BREEAM and BEPAC. There are five regional versions of BREEAM, being used in eleven countries as diverse as Canada, Hong Kong, New Zealand, Norway, Singapore, France, Holland, Italy and Spain (Doggart 1995).

EMERGY

Another method for the assessment of the environmental impact of buildings is Environmental Value Engineering (EVE). Environmental value engineering accounts for all inputs of environment, fuel energy, goods, and services (labour) in terms of EMERGY. EMERGY is calculated by multiplying the input quantities by their respective transformity. That is the EMERGY of one type required to make a unit of energy of another type. The method goes beyond traditional life cycle analysis systems by accounting for all environmental impacts. EMERGY input of different building alternatives occur during the following life cycle phases: natural resource formation, natural resource exploration and extraction, material production, design, component production, construction, use, demolition, natural resource recycling and disposal (Roudebush 1994a). Environmental value engineering was created by combining Dr. Howard T. Odum's EMERGY analysis and traditional value engineering techniques as shown in Figure 4.13 (Roudebush 1994b).

Figure 4.13 – Environmental value engineering model



Source: Roudebush 1994b: Session Assessment, paper 3:2.

This practical assessment method accounts for the environment, fuel energy, goods and services and energy inputs to built environment alternatives through 10 phase life cycle shown in Figure 4.14.

Figure 4.14 – Environment value engineering 10-phase value

PHASE A	PHASE B	PHASE C	PHASE D	PHASE E	PHASE F	PHASE G	PHASE H	PHASE I	PHASE J
NATURAL RESOURCE FORMATION	NATURAL RESOURCE FORMATION AND EXTRACTION	MATERIAL PRODUCTION	DESIGN	COMPONENT PRODUCTION	CONSTRUCTION	USE	DEMOLOTION	NATURAL RESOURCE RECYCLING	DISPOSAL

Source: Roudebush 1994b: Session Assessment, paper 3:2.

Other Assessment Methods

Another method of assessing products and compiling an environmental profile is that developed by the British Board of Agrément (BBA). The BBA assessment is weak because it is based on making an environmentally relevant statement on product or component before it is placed in a building (Hewlett and Oliver 1994). Some of the impact is due to the location and design of the building. Theses issues are considered in some methodologies but clearly not possible in the BBA methodology. The BBA investigates the properties of the product in respect safety, comfort, durability, maintenance, practicability and operational advantages, and establishes the products formulation and specification in detail. It provides an adequate input in a full building environmental assessment.

In France an assessment method, the ISEP Method (Identification des Specificités Environmentales dún Project dans le Secteur du Bâtiments) Identifying what is Environmentally Specific to a Building Project has been developed (Olive 1995:121). In this method three issues are considered very important. They are defined as the actors, impacts and criteria. They are expanded in detail with respect to each building project to illuminate the environmental impact of the project.

Another important tool towards sustainable buildings is The Environmental Preference Method (EPM) for selection of materials for use in building construction is another approach to illuminating the impact involved. It involves comparatively rating the environmental impacts of materials or components (Anink, Boonstra and Mak 1998). This method is based on the understanding that for most materials and products many environmental data are known but not in the detailed required for a Life Cycle Assessment (LCA). Products within a product group and based on the data known are ranked according to their relative preference. (Boonstra 1994:Session Assessment: Paper 4.) The ranking does not require to the same degree of accuracy as required by the LCA methodology. The objective of Environmental Performance Method of materials or products selection is that it compares materials and products currently on the market and ranks them according to their environmental impact. In brief the EPM considers environment impact throughout the whole life cycle of a material or product: during extraction, when raw materials, production phase, building phase, occupational phase and decomposition phase. The preference ranking illustrates which materials and products are more and which are less polluting. The method has been demonstrated on several demonstration projects and is widely used in The Netherlands.

The main issues considered in this assessment methodology are (Aninka, Boonstra and Mak 1998:8):

"- Shortage of raw materials.

- Ecological damage caused by extraction of raw materials.

- Energy consumption at all stages (including transport).

- Water consumption.

- Noise and odour pollution.

- Harmful emission, such as those leading to ozone depletion.

- Global warming and acid rain.

- Health aspects.

- Risk of disasters.

- Reparability.

- Reusability

- Waste".

This evaluation tool is used by over 50% of the Netherlands local authorities with good results (Aninka, Boonstra and Mak 1998:9). It "...is used as an evaluation tool in seven EU member states, for example in Thermie Building targeted projects, such as Energy Comfort 2000 projects." (Aninka, Boonstra and Mak 1998:9). Appropriate design and construction can reduce the environment impact of building over the entire life cycle.

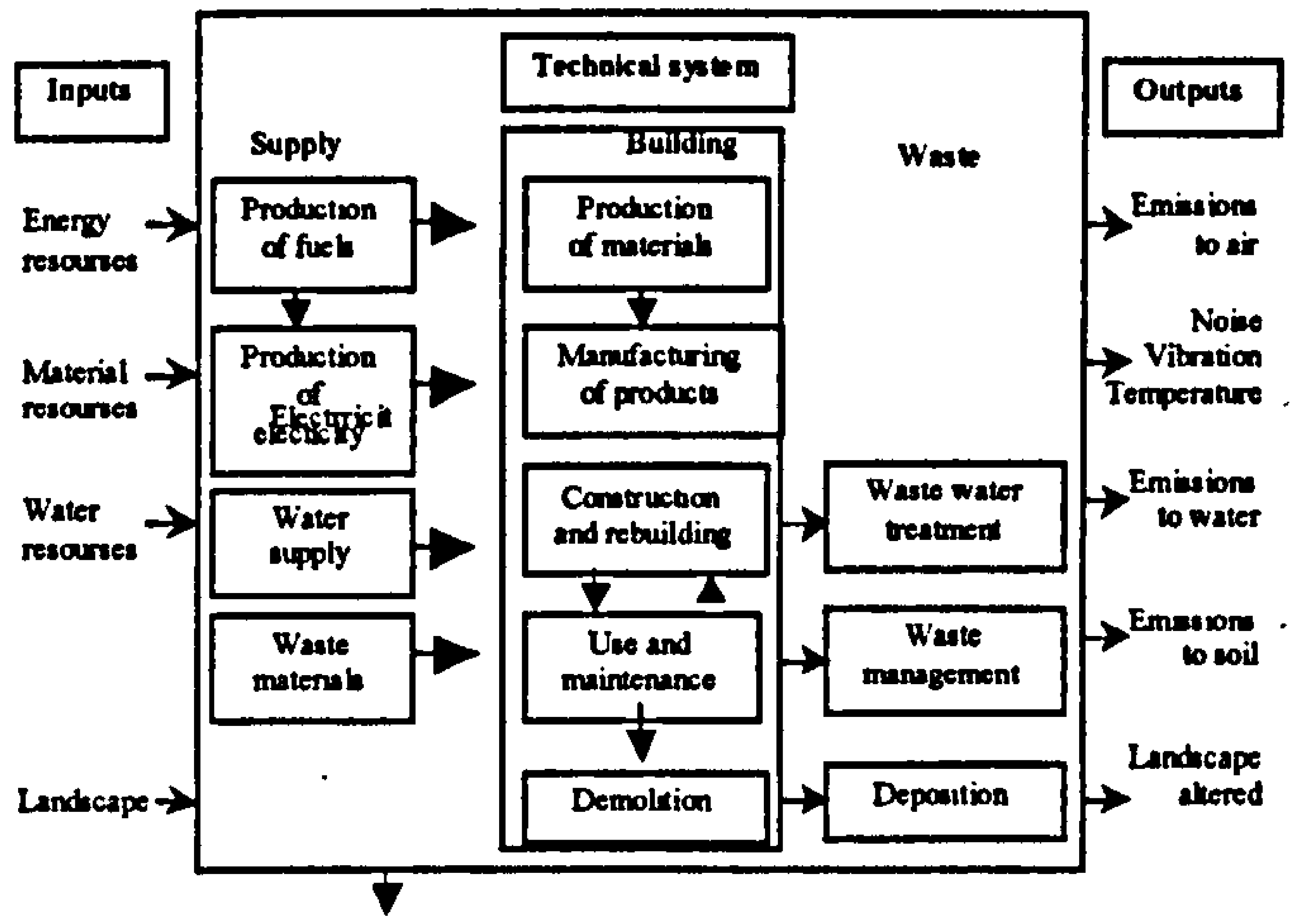
A Life Cycle Assessment method known as EQUER which stands for Evaluation of Environmental Quality of Buildings, (Peuportier, Poslter and Sommeraux 1994: Session Assessment: Paper 4) was developed in Europe and is concerned with energy and resource consumption. The aim of the EQUER project was to understand the level of energy, water and wastes during each phase of a building life. The objective was to give insights that will enable the reduction of the impacts of these resources.

The United States Green Building Council, is a non profit consensus coalition of the building industry. It promotes the understanding, development, and accelerated implementation of "Green Building" policies, programs, technologies, standards and design practices. The LEED Green Building Rating System, (Leadership in Energy and Environmental Design) is a priority programme of the US Green Building Council. It is a voluntary, consensus-based, market-driven building rating system based on existing proven technology that evaluates environmental performance from a "whole building" perspective over a building life cycle. LEED is intended to be a definitive standard for what constitutes a "green building" (USGBC 1996).

The Danish Research Institute (SBI) also recognised the limitations of the available data that drove the development of the environmental preference method. Collection and use of environmental data for building materials has therefore been a central part of the Danish Research Institute work. The Institute has focused on introducing the environmental issues into the design process of architects and engineers.

The SBI developed a software tool for the environmental assessment of materials in building projects, shows in Figure. 4.15. This work creates three categories of impacts: resource depletion, the continuing extraction of raw materials; human health impacts and ecological health impacts (Hansen 1996).

Figure 4.15 – Environmental assessment of building projects



Source: Hansen 1996.

The Life Cycle Assessment (LCA) as a Tool in the Building Management Cycle

Life cycle assessment is one method of evaluating the environmental sustainability of a building over a long term. It takes account of the impacts on the environment during the construction phase as well as during the rest of the lifecycle.

The European Union has establishing Action Programmes . The first to the fifth and finishing with the sixth. These action plans have defined objectives and targets of sustainable development. Several instruments have been written and discussed with community services and enterprises. They address the problem of compatibility between the overall development of the economic system and quality of life within the community. One tool in this analysis is the use of Life Cycle Assessment principles. In this context the fifth EU programme on environment and development (EC 1992b) is different from the previous programmes in a significant respect. At the core is the prevention principle. This has replaced the curative approach. LCA is a significant contribution to the support and explore preventive attitudes (SETAC 1993).

The EU presents the solid waste hierarchy and waste minimisation at source as the first priority. This is followed by reuse, recycling, energy recovery and landfilling at the least desirable (EC 1992b). In order to achieve these objectives it will be necessary to use LCA methodology.

Life Cycle Analysis and Assessment (LCA) is an approach that creates a detailed map of a product, process or material life cycle. This map links with environmental issues and eco-efficiency concepts. The immediate precursors of LCA were the global modelling studies and energy audits of the late 1960's and early 1970's. These studies attempted to assess the resource and environmental costs and implications of different patterns of human behaviour (WRF/PRISM 1997). LCA was an obvious extension of these ideas and became vital support to the development of eco-labelling schemes. These schemes are operating or planned in a number of countries around the world. In order for eco-labels to be granted to chosen products, the awarding authority needs to be able to evaluate the manufacturing processes involved, the energy consumption in manufacture and use, and the amount and type of waste generated. It is a quantitative analysis with all the difficulties of data requirement addressed earlier.

According to the Code of Practice from SETAC (1993), Life Cycle Assessment is defined as "an objective process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environmental improvements". The ISO/FDS standard in LCA referred in EEA (1997e) gives the following definition:

"LCA is a technique for assessing the environmental aspects and potential impacts associated with a product, by:

- Compiling an inventory of relevant inputs and outputs of a system.

- Evaluating the potential environmental impacts associated with those inputs and outputs.

- Interpreting the results of the inventory and impact phases in relation to the objectives of the study".

The recent ISO 14041 from 1997, defined LCA as the calculation and evaluation of the environment impacts associated with the life cycle of a product, material or service. Environmental loading refers to the demand for natural resources and to emissions and solid wastes. The life cycle consists of the process and transportation involved in raw materials extraction, production, use and the management of the waste. LCA is sometimes called "cradle-to-grave" assessment. LCA is a dynamic and interactive assessment process which consists of four inter related and interactive phases (MEE 1988):

1 – Goal and scope definition

In this first phase the purpose of the study is described. This description includes the intended application, audience and the reasons for carrying out the study. This includes describing the limitations of the study, the functions of the systems investigated, the functional unit, the system boundaries, allocation procedures, data requirements and data quality requirements, key assumptions, the impact assessment method, the interpretation method, and the type of reporting.

2 – Inventory analyses

In the inventory analysis, data are collected, interpreted and presented. Mass flows and environmental inputs and outputs are calculated and presented.

3 – Classification and impact assessment

The impact assessment can be divided into three sub-phases: classification, characterisation and weighting. In the classification, the parameters used in the inventory analysis are sorted into different environmental effect categories. In the characterisation, the potential contribution to the environmental loading of each effect category is calculated. In the weighting phase each environmental load is aggregated to produce the total environmental impact for assessment.

4 – Interpretation of results and evaluation

Interpretation is the phase in which the results from the inventory analysis and the impact assessment are analysed within the context of the defined goal and scope. The purpose is to reach relevant conclusions and recommendations. An LCA is generally an iterative process. The impact assessment helps increasing the knowledge on which environmental inputs and outputs are significant. This knowledge can then be used in the collection of better data for an improved inventory analysis. The results and conclusions of the LCA should also be compared to the goals defined at the beginning of the study. If the goals are not fulfilled, the LCA may have to be redesigned, or the goals may have to be adjusted. The SETAC (1993) LCA methodology is displayed in Figure 4.16.

Figure 4.16 – The Life Cycle Assessment triangle

Impact Assessment

Improvement Assessment

Ecological health
Human health
Resource depletion

Goal
And
Scope

Inventory Analysis

Materials and Energy Acquisition
Manufacturing
Use
Waste Management

Source: SETAC 1993.

This methodology has been applied to the study and management of the EU priority waste streams. One example was the Danish Environmental Project (MEE 1998) entitled Life Cycle Assessment of Packaging of Systems for Beer and Soft Drinks. The goal of the study was to update the LCA comparing the potential environmental impacts associated with different existing or alternative packaging systems for beer and carbonated soft drinks that are packaged in Denmark. The purpose of the study was to improve the decision support systems. Different systems were compared and large uncertainties were exposed. It was estimated that the most significant uncertainties were (MEE 1998:261):

- Electricity production – more specifically the environmental impacts of the long-term marginal technology for base-load electricity production.

- The market for recycled materials – in particular the effects of an increased flow of secondary Polyethylene Terephthalate (PET) from the packaging system.

- The recycling rates and.

- The transport data.

This highlights that application of LCA to solid waste management practices needs additional research to better illuminate the process, development and alternatives. With respect to the construction and demolition waste streams Kirkpatrick (1995) summarises the finding of his work as follows:

"1 – Life Cycle Inventory Analysis serves to quantify the consumption of raw materials and energy as well as releases to air, water and solid waste for a defined system (theoretically "cradle to grave").

2 – Life Cycle Impact Assessment seeks to relate those parameters quantified at the inventory stage, to measure the environmental concern such as global warming or depletion of reserves.

3 – Solid waste management practices are themselves processes requiring input of energy consumption, and resulting in the generation of atmospheric emissions, as well as discharges to a receiving water and solid waste for further disposal and/or processing.

4 – Waste minimisation at source is recognised most often to be the most common sense approach to minimisation environmental impact, associated with solid waste management practices.

5- To determine the advantages (or disadvantages) of waste management options relative to each other requires an investigation. The investigation must consider complete life cycles in which the potential advantage(s) of recycling/incineration are balanced against the environmental burdens and offset by the reduction in the use of virgin material or energy source.

6 – LCA is an effective tool for bench marking environmental performance, and can be used in comparative studies to determine the relative environmental advantages and disadvantages of products, able to carry out the same function.

7 – LCA is being used now to assist companies to quantify and assess their impacts on the environment, to identify opportunities to minimise that impact and, significantly to realise cost savings by making more effective use of available resources. In the construction industry this is true for instance on energy and raw materials requirements.

8 – There is – presently – no universally accepted and scientifically defensible way of prioritising environmental concerns.

Interestingly Kirkpatrick (1995) does not refer to the difficulties in obtaining adequate quality data highlighted earlier. He does refer to the strengths of the approach. He states that the use of LCA studies, and other environmental management tools to quantify environmental impacts, enables the identification and prioritisation of environmental programmes to minimise the impacts.

In using LCA methods the focus on sustainability, both economically and environmentally should not be lost. There is a danger that the results of complex LCA studies might be diverted to justify a market claim. A claim that might be easily challenged if different data or assumptions were used in the LCA studies.

A study by CIRIA (1995c) also puts the case for LCA. The researchers observe that LCA provides a means of ensuring that the manufacture and use of a product does not involve avoidable environment damage, and that the process *inter alia* makes optimum use of resources and energy. It also assists in the minimisation of waste and pollution. The output of that study is presented in Figure 4.17.

Figure 4.17 – Contributory factors in the life cycle impact of materials

Winning and pre-production
Source
Location
Method of extraction
Available reserves
Production stage
Constituent materials
Processing and plant
Pollution control
Resource recovery and waste minimisation
Site management
Packaging
Construction
In-service use
Health implications
Pollution effects
Durability and maintenance
After-use
Salvage and reuse
Treatment and disposal

Source: CIRIA 1995c: 25.

A study from the Generalitat de Catalunya (1996:105) highlights the difference between the LCA structure for product assessment and an LCA structure for the assessment of waste management. The principal difference it is argued is with the aim. An LCA for a product considers the entire product life cycle. An LCA for waste management addresses only a part of the life cycle but for an indeterminate number of products. This difference is an essential departure from the norm that is based on the fundamental assumption that the assessment of a product, material or component should include the entire life from cradle to grave.

Another innovation is based on the fundamental assumption that the entire Life Cycle Assessment or cost of a product should encompass the raw material extraction and processing to the production, distribution, use and return of materials to the industrial cycle or disposal. This approach deals with whole environmental life cycle (IZT 1997). These are innovative developments that should add to the value of LCA methodology.

These new approaches, linking life cycle assessment of materials and products with life cycle costs have been updated in a guide to Life Cycle Assessment or costing (EEA 1997e). The aim being to "help in environmental management and, long term, in sustainable development. The main advantage of LCA is in supporting decision making with scientific data and competence, and thereby in distinguishing between scientific facts (as far as possible) and sets of values. In this context, it is ambitious and is very close to the mandate of EEA" (EEA 1997c).

Environmental Assessment and Sustainability

There is a link between these building environmental assessment methods and sustainable development that is supported by four fundamental principles underlying sustainable development (Cooper 1995: 36). Cooper states the four principles as:

- Futurity. Acting to protect the resources and quality of life of future generations.

- Equity. Acting to correct the inequalities in the current generation.

- Public Participation: Acting to give all an opportunity to participate in decisions that affect them, and

- Environment, Acting to protect the integrity of eco-system. Eco-system is defined as a community of interdependent species together with their non-living environment, which is relatively self-contained in terms of energy flow, and is distinct from neighbouring communities (Oxford Dictionary 1995).

If the criteria currently employed in building environment assessment methods are measured against these principles they demonstrably reveal that they fall far short of what is currently meant by sustainable development. For example BREAM, BEPAC which assign credits to a building (and its management) in the context of a list of specified criteria do not address equity public participation issues. It might also be argued that they fall short on futurity matters as well.

SECTION 5: IMPLEMENTING SUSTAINABILITY

Introduction

This Section discusses a range of issues associated with implementing sustainability within a sustainable construction strategy. This information relates to the nature of concerns about sustainability developing a range of cleaner technologies and choosing better environmental solutions. The perspective of design for the environment and the consideration about health and safety in the construction industry are also studied.

Implementing Sustainability in the European Union

In the European Union, the first work towards "an examination of the arising, end-uses and disposal of demolition wastes and the potential for further recovery of materials from these wastes" was prepared in 1980 by Environmental Resources Limited (ERL 1980). This work estimated the wastes arising from demolition, their composition, the economics and environmental problems and the potential for further recovery. Recovery is defined for the purpose of the Strategic Document (Morgan and Argus 1995:Part 2:8) as to include recovery, recycling, reclamation and reuse. Definitions of "operations, which may lead to recovery," are given in Annex IIB of Council Directive 75/442/EEC, as amended by Council Directive 91/156/EEC (Morgan and Argus 1995:Part 2:8). Fifteen years later, the Report of the Project Group to the European Commission (Morgan and Argus 1995) developed this subject. In this report, Part 1 – (Information Document and Appendix 4 and 5) collected information on legislation, definitions and waste management. Data on construction and demolition waste arising and composition in member states was also provided.

The adoption of the construction-related parts of this European Union supervised project has been delayed for two years and was only implemented 1998. The group focussing on these issues was also reconvened in 1998.

There are a number of studies on the construction and demolition waste stream. One of the studies in Europe was the Odense recycling house, Denmark (Olsen 1993). The "Recycled House" is a block of fourteen co-operative non-profit flats in the centre of Odense. A significant part of the structure was built from recycled materials. Crushed concrete and crushed tiles were used as aggregate in concrete and used timber for the structure and joinery. Bricks and roof slates were also reused. The house was a milestone in the renewed efforts for large scale recycling of building materials. The large scale reuse of materials and components is an old tradition in Denmark and had been lost for decades (Olsen 1993:521). This Danish project is an important and successful demonstration of the use of these traditional principles in the modern context.

The most important instruments to achieve the objectives of waste minimisation are taxes on waste, which is deposit/incinerated or not recycled. Taxes on exploitation of raw materials are also important (Jakobsen 1998:8). There is, however, a recognition that taxes alone are not enough. It is also necessary:

– To establish national policies and Action Plans for integrated resources and construction and demolition waste management.

- To encourage recycling initiatives by grants or subsidies.

- To implement local planning and regulation of raw materials and construction wastes according to the national policies – not necessarily according to the local interests.

- To ensure processing capacity of construction and demolition waste throughout the country.

- To establish the necessary documentation (in terms of legal specifications) and standards for use of the secondary raw materials.

- To monitor the streams of raw materials and construction waste streams. This illuminates the impact on the level of raw material extraction by the use of secondary raw materials (Jakobsen 1998).

Political commitment to waste reduction is another element in the successful development of recycling programmes. The Danish recycling programmes in construction has been politically driven from highest level. It is planned and controlled by the Danish Environmental Protection Agency by means of Action Programmes that have been periodically updated.

It has been promoted by economic, administrative and technical guidance notes and instruments, which have also been periodically updated. In particular, the introduction of disposal fees and local regulations for disposal of the construction and demolition waste has been of great importance for the recycling effort.

The recycling programme has been integrated and managed as an entity. This means that all interests have been considered and all lines of business have been given the opportunity to participate. By so doing they have avoided conflicts about processing and marketing recycled products between demolition contractors and raw materials producers.

The Dutch experience is similar. Hulst (1998) considered that a fundamental impetus for change was the tax introduced on the extraction of Dutch primary (virgin) raw materials and a levy system applied to landfills. He concluded that all efforts have to be taken in a joint and long lasting operation of all parties involved. Government institutions in the beginning will have to stimulate recycling and reuse by:

- Financially supporting research.

- Providing examples by means of demonstration projects in which secondary raw materials are applied.

- Creating legislation, which enables the application of secondary raw materials.

- Taking care of intensive transfer of knowledge.

In the UK the BRE undertook a recycling demonstration project on the replacement of Building 16. "The construction of the energy efficient office on the BRE site was an ideal opportunity to carry out a demonstration project to identify and study the practicalities of reuse and recycling, regarding commercial, operational and contractual issues, and to show the commitment of the Department of the Environment and the BRE to sustainable construction." The project was successful in demonstrating the reduction in environmental impact by the use of recycled aggregates. It significantly reduced the amount of waste sent to landfill at no cost to the project. Other primary building materials were also substituted by the reuse of reclaimed components (Hobbs and Collins 1997).

There are some other experiences outside the European Union countries. For example the R-2000 programme in Canada, ReCraft 90 in Montana, the Florida House in Sarasota and the Green Builder Program in Austin, Texas (Kibert 1994a). Tansel and Tansel (1998) also refer to recycling projects implemented in the United States and Canada. They report on the results obtained and the importance of disseminating the information to obtain better participation from construction industry.

In a world context the First Conference of CIB TG 16 held at Tampa, Florida, USA, in November of 1994, was a significant step. CIB TG 16, is the one of the Task Groups of the International Council for Building Research Studies and Documentation (CIB) specially focused on Sustainable Development and Construction initiatives. It was a well attended conference including researchers and practising builders sharing ideas and information on the recent trends and practices in the move towards sustainable construction. There was also the First International Conference on Buildings and the Environment held at Garston, Watford, UK in 1994 held at the BRE and organised by another Task Group of the CIB. The objective of the conference was to improve the cross-links between the many people working, in different parts of the world, on different aspects of environmental assessment of buildings. It enabled the exchange of current knowledge and understanding, and helped those working in the field to focus their future work (Hobbs 1996).

The prioritising of the construction and demolition waste stream by the EU should further encourage the interchange of information between the member countries and the introduction and improvement of legislation and regulations developing construction and demolition waste practices. For example, in UK the Hobbs (1996) report that there was an increased interest and support for those who were concerned with waste management which includes those who produce and handle it. It is now recognised that effective management, instead of simple disposal of waste, can bring important benefits. These potential benefits from the formulation and implementation of a waste management policy based on the best practicable environmental options include:

. Improved environment credentials – an increasingly valuable asset.

. Saving in disposal and transport costs and increased revenue from reuse and recycling.

. Reduction on material purchased.

In Portugal, the Institute of Waste Management, a part of the Ministry of the Environment, has convened workshops and seminars on the issue and started a joint research project with the municipality of Lisbon. This project is a joint research project with the Instituto de Ciências Aplicada e Tecnologia (ICAT) which belongs to the University of Lisbon (UNL) (INR/CML/ICAT 1997). It will be discussed further in Chapter 8.

The need for lifestyle and behavioural change together with the psychological and social impediments to that change has been discussed in earlier chapters. Those concerns must drive changes in the construction sector. It is recognised that the construction sector, especially building, is undergoing far-reaching changes (European Foundation for the Improvement of Living and Working Condition 1991:9). These changes have a variety of aspects:

. Technical change, with the emergence and application of new construction procedures, new equipment and materials.

. Market change, with a reduction in the number of large scale housing programmes and a change away from the construction of new buildings and towards renovation and restoration. This is common to most EU countries.

. Organisational change, with the search for productivity gains no longer confined to the level of each separate phase of the construction project but looking at the overall cohesion of the process itself. This overall approach relies, in particular, on improved communication between the different participants, both upstream and downstream of the process.

. Structural Change, with a trend developing in some countries towards the breakdown of functions and the fragmentation of companies. This leads to a cluster of subcontracting arrangements around a supervising employer, or general employer, pared down to its most basic form.

Non of these changes are driven by the sustainability agenda. The changes, as with others sectors of industry, have been driven by:

- The opening of frontiers and the creation of the single internal market in 1992

and

- The social dimension and specific problems experienced by the sector in this area.

Tenah (1995) have studied the resistance to change by the groups involved. The resistance, they observe, is often a result of difficulties in dealing with alteration to comfort, familiarity and ease that comes with the status quo. This can be coupled with a lack of motivation for change because the reasons for change have not been communicate properly. Studying the public resistance to the use of electronics data systems, Tom (1991) observed that to deal with resistance to change, "we have to understand the reasons for it, preparing users for the change by helping them to understand the nature of change and why it is necessary".

According to Tenah (1995:167) there are several different kinds of resistance to change. They identified interest groups that resist changes in linking and prioritising environmental criteria in the construction industry. The resistance to change was based on a self-sustaining organisational structure tailored for the current environment and technology. Changes in the environment and technology created stresses on those structures. The groups and systems identified were:

1- Resistance by contractors.

2 - Resistance by architects and engineers.

3 - Resistance by the judicial system.

4 - Resistance by the legislative system.

5 - Resistance by established institutions.

6 - Resistance by union membership.

They argued that some types of resistance to change were related to resistance by individuals while the remaining types were related to societal structures. Barret (1993) studied resistance to change and levels of change from a managerial perspective. He observed that attitudes are interesting but it is behaviour that matter in the end. In his opinion, the process is more complex than that suggested by Tenah (1995:167). He quoted Kast and Rosenzweig (1981) to support his view. He described the various stages in changing the knowledge base and its impact on changing individual and group attitudes and behaviour patterns.

With respect to sustainable practices, whatever mechanisms for change are adopted it will be essential to have the government support for implementation. For the construction and demolition waste stream the objectives are prevention, reuse and recycling of the waste. The mechanisms will include specification, regulation and taxes on natural resource extraction and landfilling. levies. There will also be a need for market regulation and, as discussed earlier, a global and integrated management policy (Morgan and Argus 1995).

SECTION 6: THE ROLE OF THE CLEANER TECHNOLOGIES, ECO DESIGN OR DESIGN FOR ENVIRONMENT

The production of wastes varies accordance to different manufacturing practices. The amount and composition of wastes depend upon the applied technology and the price and nature of the raw materials. Using the same technology vastly different amounts of wastes can be produced by similar processes. Eco design or design for the environment when applied can minimise the waste stream (Larsen and Olsen

1991:21). These environmental solutions and considerations are discussed in this section.

Cleaner Technologies

Cleaner technologies, eco design and recycling to support a waste minimisation strategy are the challenge for the 21st century (Pereira 1997:15). A starting point for cleaner technologies is the harmonisation of terminology and criteria (OECD 1987). It is important to have clarity about the meaning of, and criteria for, cleaner technologies. This is necessary to evaluate the levels of quality of the technologies under consideration. At the Conference on Environment Technology in Amsterdam in 1987, Akker (1992) also observed that clarification of terminology and criteria must be a priority.

- Roustain et al. (1996: 175) defined cleaner technologies as a manufacturing process which:

- Reduces the quantity of effluents, which pollute the environment.

- Makes the most rationale use of raw materials and energy and at a reasonable economic cost.

This perspective of reasonable economic cost is essential to overcome the actors' resistance to change.

Akker (1992) defines two types of cleaner production based processes by the levels of benefit they offer.

"Type 1 is "highly beneficial" because it completely eliminates the pollution control costs and reduces the manufacturing cost. Type 2 "marginally beneficial" because it reduces the pollution control cost but increases the manufacturing cost whilst the overall cost of production is still slightly reduced. No matter how beneficial a Type 1 cleaner production may look to the environmental professional, it will be seen to be only a marginal beneficial Type 2 cleaner production by companies that perceive it to be a risk, especially those averse to risk, such as small companies. A factory's perception about cleaner production is influenced by internal and external factors. Internal factors include management's knowledge of the technology and the company's size; external factors include environmental legislation and enforcement. The following activities will help to counteract these barriers to the successful introduction of cleaner production:

- Dissemination of information about cleaner production.

- Publicity about the benefits of cleaner production to arouse awareness.

- Comprehensive legislation coupled with firm enforcement."

Referring the Dutch experience in promoting environmental technology. Akker (1992) observes that the main thrust of the Dutch governmental policy to stimulate cleaner technology is:

- "Most of the subsidy must be used directly for the stimulation of industrial projects that show a clear relation to practical application.

- Industries to prepare project proposals in priority area(s), as defined by to the priority target groups of environmental policy indicated by the government.

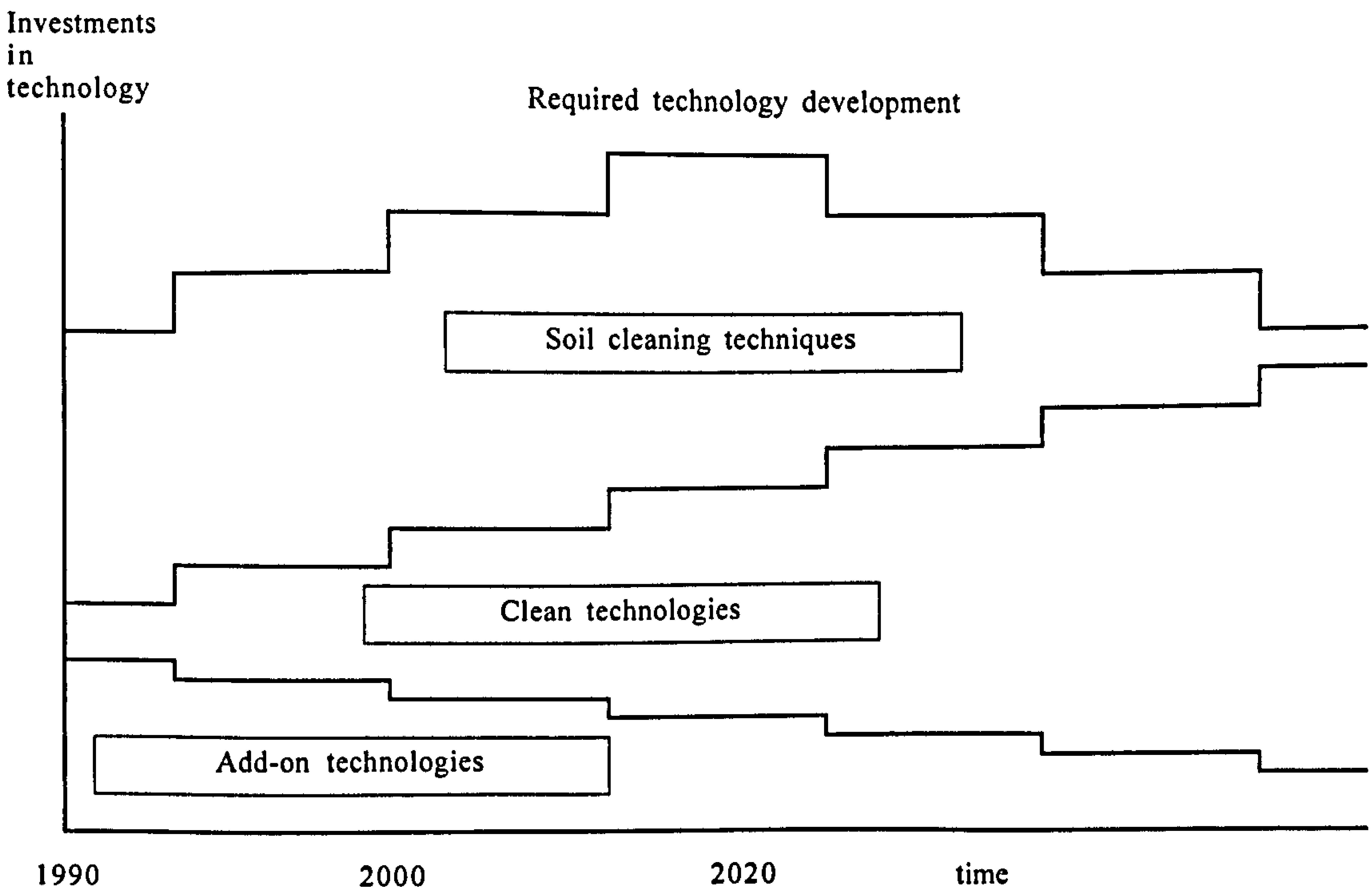
- Research institutes and universities establish a working relationship with industries interested in applying the cleaner production process or products concepts.

- Industries must give priority to emission reduction technology at the source, such as process integrated solutions for emissions reduction, resource recovery, and use of environmentally sound raw materials.

- Project results be applicable to industries in other industrial sectors." (Akker 1992)

According to Akker (1992:68) the Dutch government's policy is designed to influence development in the direction of preventive technologies. Figure 4.18 shows the investments in technology correlated to the required technology development required by the Netherlands Cleaner Technologies programme.

Figure 4.18 – Investments in technology versus required technology development



Source: Akker 1992, Fig.7-1: 69.

The construction industry needs to adopt cleaner technologies as a contribution towards achieving sustainability. Examples of cleaner technologies that could be adopted by the construction industry are:

- The manufacture of products and materials with non-toxic components and low embodied energy.

- The development of pre-fabricated elements designed for reuse or for efficient recycling.

- The development of "intelligent buildings". Intelligent buildings are buildings with computer controlled management systems optimising safety requirements and energy and resource consumption.

Design for Environment

Design for environment is an overall goal of sustainable construction (Gradel and Allenby 1996). There is detailed and comprehensive information published by various sources related to the issues of efficiency energy, water and materials in this context. The design phase initiates the environmental agenda with respect to the life cycles of a building. Fox and Murrel (1989) published a design guide focussed on the environmental impact of building materials. It is one of a number that is designed to provide information on materials and processes in a form that is useful to architects and designers and be comprehensible to clients. Barnett and Browning (1995) observe that these concerns and their practical application are core contributions to the development of sustainable buildings. They argue that it is necessary to observe five principles:

- The importance of longevity and the need to monitor the life span of building.

- The philosophy of building versus building style.

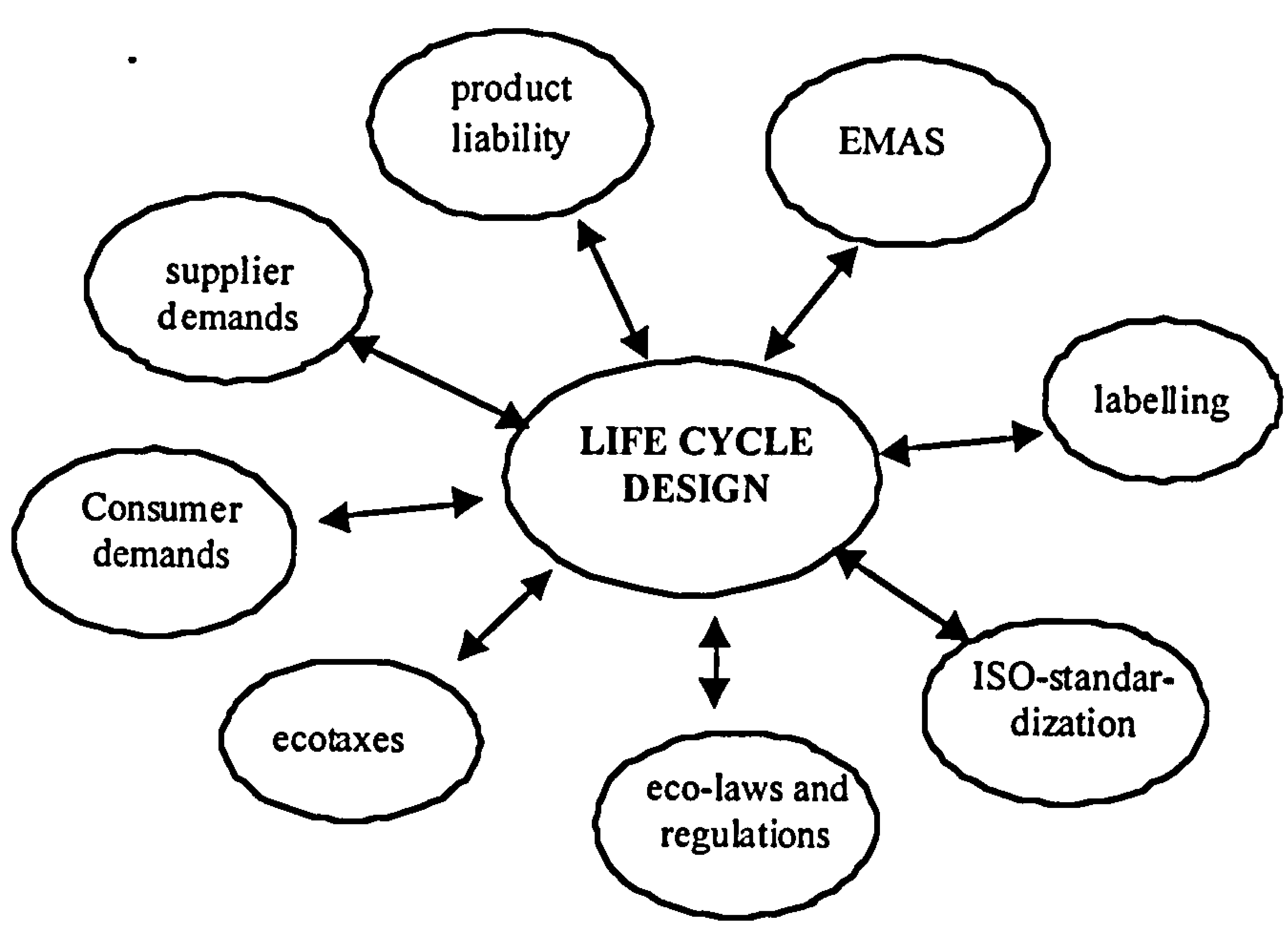
- The cost control focussing on more liveable and economical building.

- The importance an integrated approach.

- The energy efficient and minimising resource consumption.

The eco-labelling of building materials has evolved from these environmental concerns. The scheme developed within the EU Regulation 880/92 (EC 1992c) is a sound step towards achieving sustainable construction.

Figure 4.19 – New influences on product design



Source: IZT 1997: Fig. 3.1:22.

New influences on product design are shown in Figure 4.19. Hewison (1995) explored the interaction between technologies and environment and concluded that there were some guiding issues. He set them down as follows:

- The "Clean Green" trade opportunities in major markets with "green consumers". The need to develop environmental marketing from "image" to "reality".

- The dichotomy between "free trade" and environmental issues. Those issues include how to deal with eco-labelling schemes, packaging laws, environmental charges, taxes and subsidies in the context of world trade competitiveness.

- Intellectual property rights focus on the protection of intellectual property in commercial products. When the products derive from natural resources the intellectual property rights fail to acknowledge the value of protecting the biological and genetic resources upon which the commercial products are based.

- The way towards a framework for trade and the environment. The General Agreement on Tariffs and Trade (GATT), now the World Trade Organisation WTO, is the primary multilateral forum for negotiating international trade issues and is emerging as the central forum on trade and the environment. Currently just over one hundred countries are party to the agreement giving the WTO significant influence. The GATT placed little attention on environmental issues in the past. However since December 1990 considerable analytical work has been undertaken giving insight into the range of different concerns of different. The OECD is also playing a significant role in these deliberations. The OECD operates mainly as an international "Think tank" where analysis is undertaken to inform negotiation prior to establishing the rules (Hewison 1995:62).

The influence of the rules governing international trade is significant. Design for the environment will not feature strongly in product design if the sustainability agenda is not adopted as a key influence in the establishment of the rules governing international trade.

The adoption of cleaner technologies and eco-design or design for the environment, are close linked with the adoption of other tools and methodologies. According to Anink, Boonstra and Mak (1998) environmental building design was a freakish business, carried out by a handful of dedicated designers with little or no source information. It is of great importance to society that the building sector is involved in designing for the environment because, as has been noted earlier 50% of material resources taken from nature are building-related. In addition over 50% of national waste production comes from building sector and 40% of the energy consumed in Europe is building-related.

(Anink, Boonstra and Mak 1998: 10) argue that the best strategy to respond to these sustainable issues are:

- The prevention of unnecessary use and efficient use of materials.

- The use of renewable and recyclable sources.

- The selection of materials with least environment impacts.

An EU study addressing the waste issue provided a comparative review of the opportunities for minimisation in fourteen key sectors of manufacturing industry. The emphasis was on small and medium sized enterprises as they have a particular need for information and training in the context of the globalisation of the market. The study aimed to stimulate manufacturers into thinking about their own production processes and to inform public officials responsible for promoting waste minimisation. The study concluded that companies should adopt a design for environment strategy and apply it to their factories The adopting of cleaner technologies would be implicit in that strategy (Witteven- Bos/EurEco 1997).

SECTION 7: HEALTH AND SAFETY IN CONSTRUCTION INDUSTRY

Concern for safety and health in the construction industry assumes a high significance because there is a correlation between accidents and deficient equipment and the lack of preparation, training and supervision of the process (Dias and Pires 1998:86). The number of accidents in the demolition sector is not well identified in Portugal. There is no special trade association for the demolition sector in Portugal. There is a trade association for building and civil construction works but that association does not pay much attention to the demolition process. It is well recognised that accident numbers could be considerably reduced with better supervision and organisation on site. The EC Directive to the construction industry (92/57/CEE) and the corresponding Law Decree 155/95 defined safety and healthy co-ordination and prevention instruments. The key issues for prevention of accidents and the protection of health are:

- Safety and Health Plan.

- Technical information available.

- Easily communication between actors.

The preliminary data from accidents in construction industry shows that they are reduced in companies where training is done and information disseminated (INE 1998).

Pledger (1977:59) listed, in order of frequency, the causes of accidents as:

- Fall of person on site.

- Accidents caused by:

  . Falling materials or sections of structure.

  . Unintentional collapse of parts of buildings.

  . Lifting operations and unprotected machinery.

  . Fires and explosions (this refers to unintentional explosions of gases, etc.).

  . Electric shocks.

  . Lifts, obstructed accesses, etc.

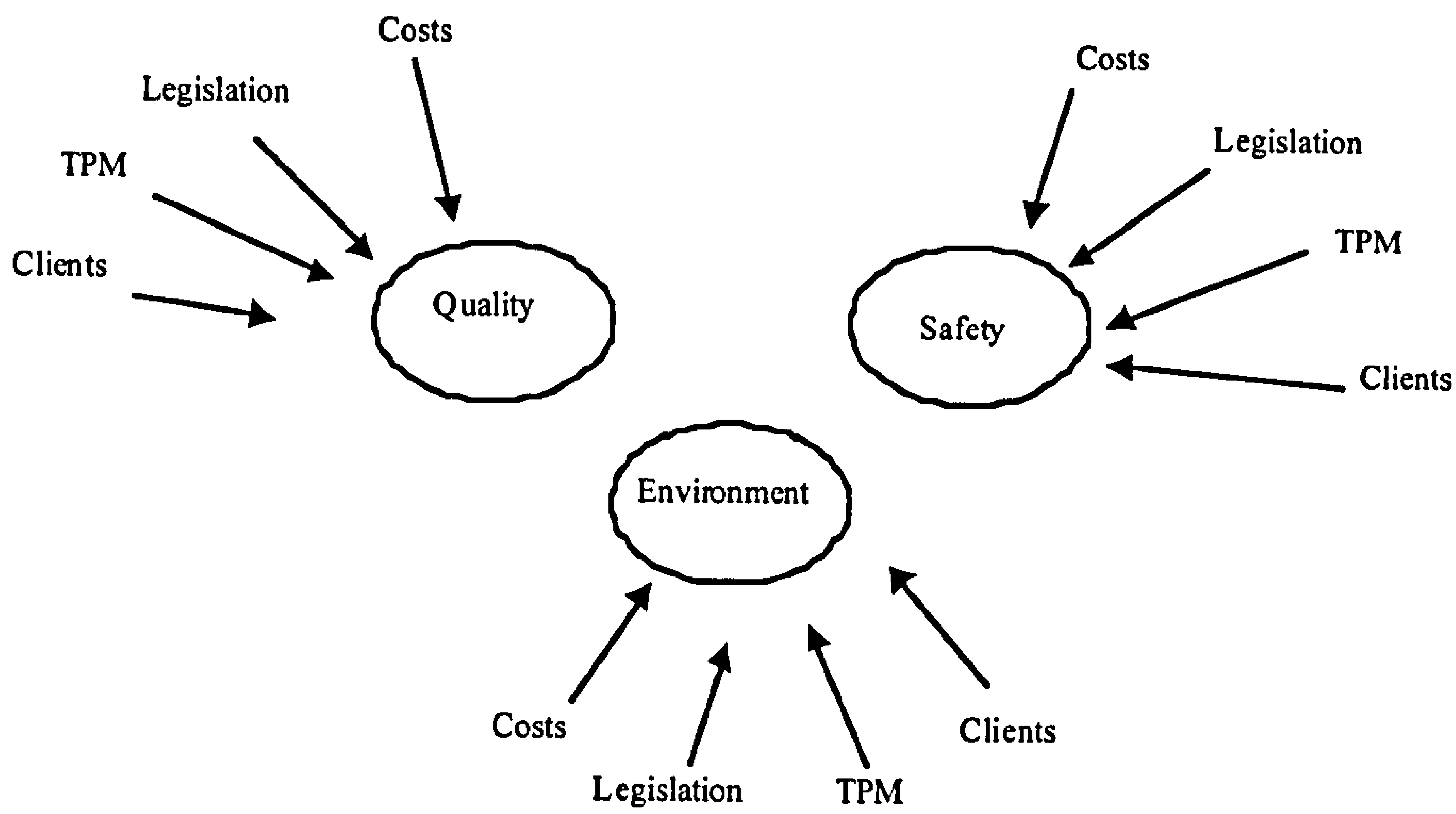
Pledger (1977) argues that demolition will not necessarily be conversant with the structural nature of what is being taken down, and guidance in this respect should be competent and continuous. The supervision of demolition should only be entrusted to someone who is widely experienced in demolition and in building construction.

Sometimes the workers involved in selective demolition are different from those involved in the "stripping out" process or the dismantling phase. This occurs mainly when there are different contractors that are involved on the works. According to Pledger (1997) a plan of the proposed sequence of operations should be formulated and explained to and discussed with the site operatives

The improvement of safety and health practices was recognised as enhancing quality and productivity on construction sites. Gibb (1996:5) presents a Total Project Management of Construction Safety, Health and Environment guide published by the European Construction Institute (ECI). Its objectives are to promote a genuine and sustainable improvement in the performance of the construction industry in the areas of safety, health and environment.

Ayoade and Gibb (1996: 11) report on preliminary results from ongoing research into management systems to control construction quality, safety and environment (QS&E). A questionnaire was distributed to all European Construction Institute (ECI) members. The questions were combined with questions on the implementation of the ECI's manual "Total Project Management of the Construction Site". Currently ECI members comprise 17 client/owner, 37 contractors/construction organisations, 9 consultants and 5 industry associations. All the respondents found the manual easy to understand and considered the level of detail "about right". 25% stated that they often referred to the manual regularly. 35% often and the remainder, 40%, occasionally. This level of use was also reflected in the responses to questions relating to the manual's distribution. 60% of respondents were using the manual as a basis for resolving their safety problems. 25% said that the manual would also be used as a part of their staff safety and healthy environmental training programme. This illustrates that it was seen as a significant influence on the organisation's processes. Finally, 75% stated that copies would be available in their organisation's library of safety publications. A number of findings focus on the pressures driving increased integration of quality, safety and environment systems (see Figure 4.20).

Figure 4.20 – Pressures causing integration of quality, safety and environment systems



Source: Ayoade and Gibb 1996: Fig. 3:15.

In Portugal, the qualitative approach to these safety and health problems are in accordance with Council Directive 92/57/EEC of 24th June and applied to national legislation by Dec Lei nº 155/95. This legislation requires a Safety and Health Plan for building and civil engineering works. In 1996, Cabral and Roxo (1996) published a guide for the Portuguese construction industry, to encourage them to adapt to these updated rules and procedures. They essence of the advice is:

- Risk assessment.

- Removal of risk from construction industry activity.

- Eliminating risks at source.

- Adapting the construction works for buildability.

- Attention to the evaluation of technologies.

- Work planning and organisation.

- Team working developed.

- Information and training.

Cabral and Roxo (1996) also argues the case for understanding and reducing construction industry costs and improving the quality of construction works. The need to integrate, under ISO 9000 guidelines, safety and quality systems is also highlighted.

Coble (1998:55) has demonstrated the necessity to integrate these issues with those of environmental protection. From an owners perspective he argues that worker protection and environmental protection have distinct characteristics but have a common foundation. That common foundation forms a basis for commonality in planning for construction, the owner's involvement in the development of a building and the training of workers.

A Portuguese guide (Miguel 1995) on hygiene and work safety focuses on prevention of professional risks in the construction industry. It is based on the principles and rules contained in EC Directive 89/391/CEE and addressed to both workers and managers.

Summary

This chapter discussed the main characteristics of sustainable construction. It dealt with the building life cycle and the deconstruction process at the end of the life. Sustainable building life cycles are studied together with waste prevention and minimisation. Waste prevention and minimisation has the highest priority in the European waste management strategy. The objectives of assessing and implementing sustainable construction are also discussed. These discussions included the study of Environmental Impact Assessment (EIA). Waste and environmental audit and the presentation of environmental management auditing schemes were also included. Energy consumption and embodied energy in products and materials together with their associated impacts are discussed in the context of the construction industry. The assessment of sustainability in construction and the principal assessment methods are explained and discussed. The use of Life Cycle Assessment (LCA) is discussed as an essential tool in the move towards sustainable building. The difficulties and constraints of implementing sustainability are discussed. The resistance to change in attitudes and behaviours in the deconstruction process are also discussed and highlighted. The roles of cleaner technologies, eco-design, or design for environment, towards more sustainable buildings are discussed. Finally health and safety issues in construction works are highlighted.

CHAPTER 5:

THE DECONSTRUCTION PROCESS

"In the Nature nothing is lost, nothing is created. Everything is transformed"

Lavoisier (1743 – 1749)

INTRODUCTION

The ability to deconstruct a product is essential to the sustainability concept and must be considered at conception of a new building or structure.

Deconstruction should be seen as an environmental response for construction sustainability (Wyatt 1994:113). When a building is deconstructed a demolition waste stream is generated. The qualitative and quantitative characteristics of that waste stream need to be established. This Chapter is divided into four main Sections, seeking to explain the process and its characteristics. Section 1, explores the deconstruction process. It focuses on the technical considerations related to the dismantling and selective demolition phases. The nature of the fieldwork to obtain the data for the utilisation of materials and products from the waste stream is also explored. The quality of the data obtainable from that work is discussed. The role of management in minimising waste from the construction site is considered. Also studied are the main constraints to implement the satisfactory management of the waste stream. Section 2, addresses the definition of the debris trail. It is necessary to define the quantities and qualities of the material in the debris trail. The results of studies undertaken in countries other than Portugal are presented illustrating the characteristics of the debris trail. Section 3 concerns construction and demolition wastes in European countries particular reference to the Portuguese situation. Section 4 concerns hazardous materials in building construction. It deals with hazardous materials present in building and the methods of dealing with hazardous materials in the deconstruction process. Soil contamination resulting from the use of hazardous materials is also studied. The necessity of avoiding using these materials in the future is discussed. The last Section, Section 4, focuses on the economic issues of the deconstruction process. It is intended to illuminate the economic feasible of incorporating the implications of environmental agenda into the deconstruction process.

SECTION 1: DECONSTRUCTION

Introduction

This Section concerns the deconstruction process. It focuses on the technical considerations related to the dismantling and selective demolition phases. It addresses the issue of the quality of data from the fieldwork. Sustainable construction practices from the past are considered and the relevance to current deconstruction practices is highlighted. The main constraints in the development of the process are discussed. The role of management in minimising waste from the construction and demolition site is considered. The main constraints to implement the satisfactory management of the waste stream are highlighted.

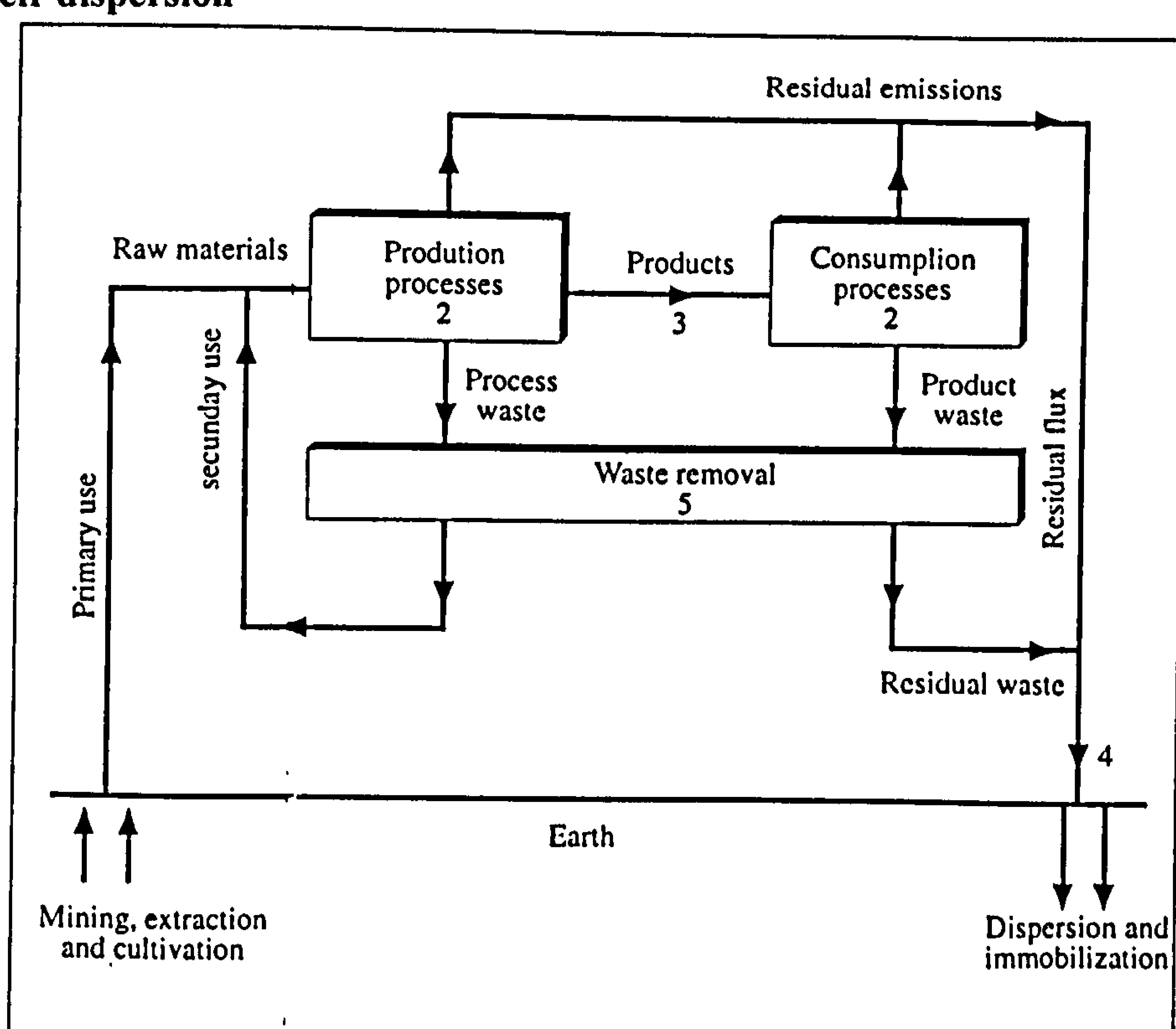
Deconstruction Process

Our ancestors built their shelter in close harmony with nature. They, probably, did not consciously consider the environmental advantages of preserving nature (Don 1994:156). It was intuitive. It is different from the all lead to past civilisations naturally using recycled materials in their construction and civil engineering works.

For example the use and reuse of clay, stone and timber, as construction materials are evident from the earliest times of human settlement. Current generations need to learn from these practices to move towards sustainable development. Only in this way can the exhaustion of raw material supplies and the accumulation of polluting substances in the environment be prevented (Don 1994:159).

Don (1994) from the Netherlands is developing proposals giving insight into the technology development necessary to move towards a sustainable material cycle. His proposal, shown in Figure 5.1, is for a material cycle with maximum closure that is fundamental to the concept of the sustainable or eco society.

Figure 5.1 – Material cycle of maximum closure. Residual emissions and their dispersion

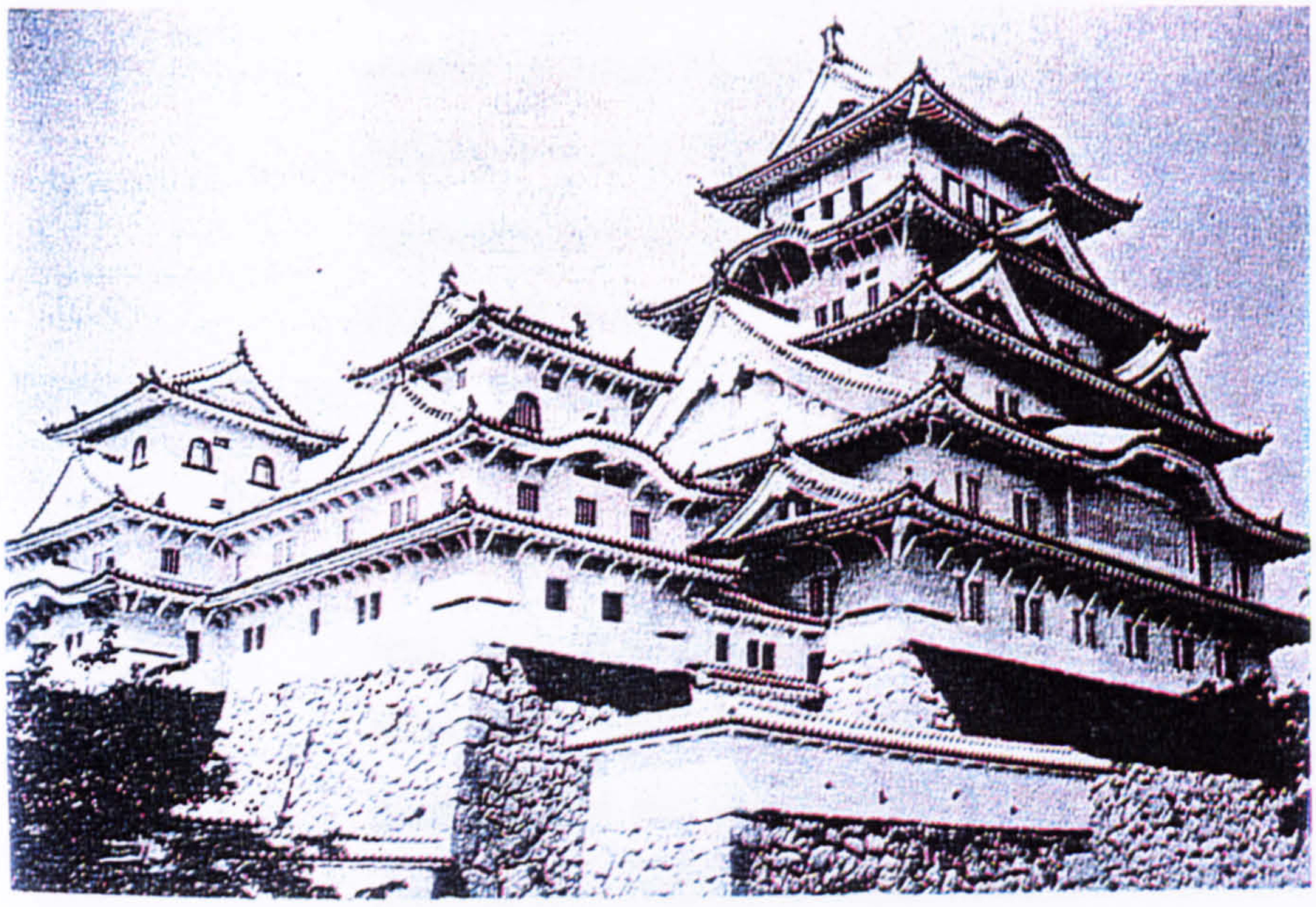


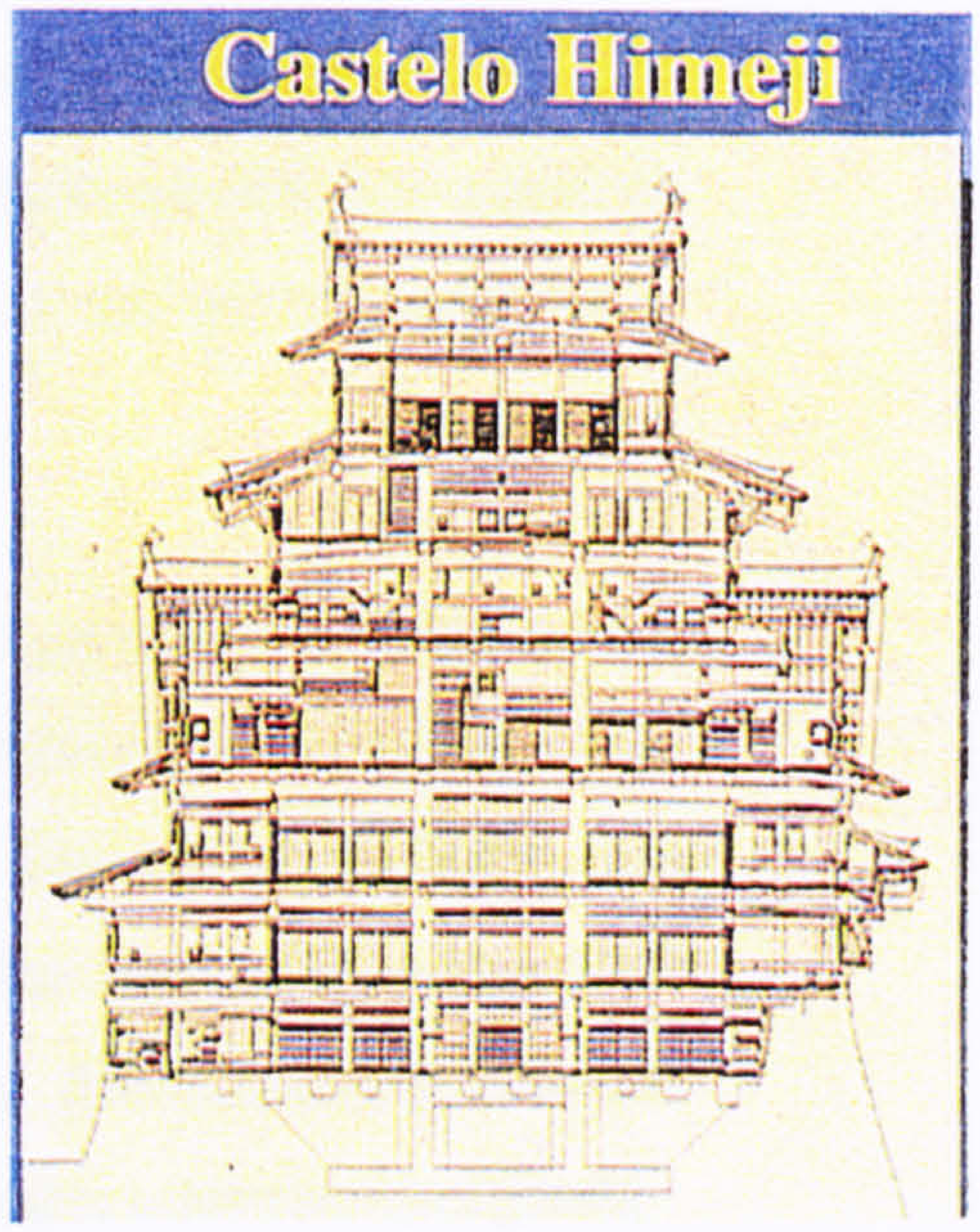
Source: Don 1994.

. Demolition and recycling of concrete structures involves significant energy consumption. This is in addition to the energy used in concrete production that is around 1000 kWh/ton according to Silva and Farinha (1994:74). Silva and Farinha (1994:71 Fig. 17) also observed that concrete requires 2500 kWh per cubic metre to produce. That is 1800 kWh per person per year in Portugal based on 1994 consumption and is increasing. It is not possible to continue developing in this way. There is a need to design for deconstruction. The dismantling process that will result will use significantly less energy. It will also improve the ability to adapt the buildings easing maintenance work and delaying the onset of demolition. Adaption and reuse of building is a fundamental waste minimisation strategy but where that is not possible the recycling materials should be maximised. It saves significant energy consumption.

An example of easy deconstruction from the Middle Ages is traditional Japanese timber building (Silva and Farinha 1994). Here the buildings were designed with wood panels that could be easy dismantled and reuse again. This concept was used in the Himeji Castle in Japan. In that building all the timber structure and timber materials were based on a masonry foundation and could be dismantled. The joints were designed for deconstruction to enable the easy replacement of decayed timber components.

Figure 5.2 – Himeji Castle in Japan





Source: Silva and Farinha 1994:72.

The maintenance of these timber buildings was undertaken every three hundred years. Deteriorated elements were removed, repaired and mounted again (Silva and Farinha 1994). The framework does not utilise nails and the joints were complex.

This concept has been used throughout the centuries. A significant example was the Crystal Palace in London, a project from the architect Paxton for the 1851 London Exposition in Hyde Park. It was a bold design for that time, made of steel, cast iron, glass and timber elements. Some experts argue that this building marks the beginning of modern architecture (F&BO/DTI 1998). It was dismantled at the end of the exhibition and rebuilt again at a location in South London that became known as Crystal Palace. A fire finally destroyed the building in the middle of the 20th century.

Following the success of London's Great Exposition, Portugal under the oldest European Treaty between countries (The Treaty of Windsor) presented its first big International Fair. The Portuguese King D. Luís I and Queen Maria Pia opened the Porto International Exhibition of Arts, Manufactures and Agriculture. The building in which the exhibition was open was called the

Crystal Palace. It was modelled on the British Crystal Palace and built with a similar structure by the British architect Thomas Diller Jones with Mr. F. W. Shields the chief engineer. This design option was chosen so that it to could be deconstructed at the end of the exhibition and rebuilt for use on another site (F&BO/DTI 1998).

The advent of reinforced concrete structures produced building which were easily and rapidly constructed. They had improved fire resistance and less time was required to train the labour force. The advent of these new materials with the clear construction, cost, durability and safety advantages marginalised the deconstruction concepts. Efficient deconstruction concepts must be reintroduced to move forward on the sustainable construction agenda.

At the design stage the deconstruction technology of a building must be given similar weight as the construction technology of a building. The construction for deconstruction is highlighted in "Design to Demolition Strategies for Green Buildings" published by the US Department of Energy and Public Technology, Inc. The objective of this work is to demonstrate the appropriate methodologies for the design, construction, operation and maintenance of environmentally friendly buildings (USDOE/PTI 1999).

The deconstruction process needs to focus on the maximum utilisation of the materials released from the process. This new philosophy involves all the actors in the building process and begins at the design stage. This concept of deconstruction extends the concerns and goals of the process beyond that of the traditional demolition process. Deconstruction is a more appropriate solution to the environmental questions whilst satisfying the technical and economic constraints. It maximises the utilisation of released materials and components in a technically competent and economically feasibility process.

The nature of the deconstruction process depends on several factors related to the characteristics of the building. Other factors include the characteristics of the demolition contractors, workers' training, the equipment used, markets, costs, institutional support and a global environmental awareness. The deconstruction process normally refers to the demolition phase. However the deconstruction process is one that has two different inter-linked sequential phases:

- The dismantling phase.

- The selective demolition phase.

All the participants in a deconstruction process must observe the general rules and the priorities related to building deconstruction. The Junta De Residus established the priorities for the improvement of the processes.

The priorities set down by the Junta de Residus (1995a) are:

1 - The dismantling process must have a flow. This is necessary to maintain the overall stability of the elements of the structural framework.

2 - The process begins with the dismantling of the roof and must finish at the ground floor or basement.

3 - The dismantling sequence must begin with the coverings and finishes and end with the structural elements ensuring safe opperations.

4 - The dismantling or stripping out of the building elements or components will start from the top and descend floor by floor.

5 - Special attention should be paid to the structural elements in tension or compression and those with special structural functions.

The general rule is to dismantle the building elements in the opposite order to that which they were installed. The dismantling, or stripping out phase, is followed by the selective demolition phase.

The process begins with the removal of plastering and other similar elements followed by the interior walls and the infil elements making up the façade. Finally the structural elements are demolished. Special care must be taken with contaminated elements during all phases. Special consideration must be given to dealing with site contamination and the eventual necessity of soil remediation where that proves appropriate (Soesilo and Wilson 1997).

A very important tool in the process that leads to sustainable practice in dealing with the construction and demolition waste stream is the Deconstruction Execution Project (Junta de Residus 1995b). The project had the follow objectives:

- To facilitate all the actions and the co-ordination of all the actors in the process.

- To ensure an efficient degree of materials and components recovery.

- To guarantee the necessary overall and personal security.

The published results covered four areas:

- The process contents, the methods and processes which must be used in deconstruction works.

- The participants co-ordination and responsibilities.

- The planning of the works, recycling operations and final recovery.

- The final destination, to landfill or incineration, of the waste that is not possible to recycle.

Sound practices for reducing construction and demolition wastes have been proposed by UNEP/IETEC (1996b:118). The principal actions proposed are:

1 – Waste prevention can be promoted through inventory control and return allowances for construction material. This ensures that materials will not get disposed of unnecessarily.

2 – Selective demolition. This involves dismantling, often for recovery, selected parts of buildings to be demolished before the wrecking process is initiated.

3 – the adoption of on-site separation systems, using multiple smaller containers in place of a single roll-off container or compactor.

4 – Crushing, milling, and reuse of secondary stone and concrete materials. There can be a tie-in to approved road construction materials specifications.

Construction and demolition debris is generated regularly in urban areas as a result of new construction, demolition of old structures, and regular maintenance of buildings. These wastes contain cement, bricks, asphalt, wood, and other construction materials, which are typically inert. In addition, and mainly in industrialised countries, they may contain some hazardous materials such as asbestos and PCBs. Municipal solid waste landfills can be rapidly overwhelmed by the quantity of waste generated and city authorities need to control unauthorised tipping since these locations can become mini-dumps. Very large volumes of demolition waste are generated in earthquakes and during wars but the management of that waste is not a focus of this thesis.

It is important to have the reason for demolition and knowledge of the building characteristics for efficient deconstruction. To obtain that knowledge it is necessary to do a building survey. The survey will provide information on the following items:

- The building age.

- The principal materials.

- The construction technique utilised.

- The building structure framework.

- The building structure framework alterations.

- The actual location of construction elements that could affect or contribute to the structural performance and stability of the building.

- The location and condition of the services and mechanical installations.

- The stability and safety of the adjacent buildings.

A deconstruction philosophy, deconstruction or disassembly method is explained in a deconstruction cascade route (Wyatt 1994:117). Wyatt developed a simply model as a response to what they describe as Construction Environmental Stewardship. The deconstruction cascade route is a model with a number of respective waste stream options. The model demonstrates the potential for the involvement in building disassembly operations of the waste management industry, material and component manufacturers and building and component designers.

The deconstruction process has similar features to the construction process. Project documentation referring to dismantling and demolition of a structure is similar to that prepared for a new construction or rehabilitation project. The documentation must contain a design for the project, the tender documents, responsibilities and pricing sections.

There is a need for a manual for project communication. It must contain information about the way in which drawings and written data concerning the project are transmitted between parties and to the site. It is an essential document for any civil engineering or building work. The manual, should be developed by discussion and working groups within the industry rationalise project-site communication. Cabrita, Aguiar and Appleton (1993) posit the objectives of the recommendation and rules as:

- To obtain a wider and more orderly range of information, without a great increase in the time and resources spent.

- Gradually to fit the supplied information to the common needs of users on site.

The project has two parts. The first part is Descriptive Memory, which is further sub-divided into two parts. The first subdivision provides the reasons for the project and highlights the main aspects of the works. It includes all the significant aspects from the survey, technical aspects that justify the technical solution proposed, technical characteristics, safety rules to adopt in the context of the technical characteristics and condition of the building. It also contains a justification of the operations, materials storage, recycling plant and financial conditions of the process. The second sub-section must contain a description of the technical solutions, the techniques and the sequential steps of the deconstruction.

A process protocol, developed at the University of Salford (TIME Research Institute 1997) is pertinent to this issue. The process protocol breaks down the design and construction process into ten distinct phases. These phases are grouped into four broad stages, namely Pre-Project, Pre-Construction, Construction and Post-Construction. The Pre-Project phas relates to the strategic business considerations of the potential project, which aims to address the clients need. Throughout the Pre-Project phase the client need is progressively redefined and assessed with the aim of determining the precise need for a solution involving a construction project and to secure outline financial authority to proceed to the Pre-Construction phase. The Pre-Construction phase commences after approval to proceed with the project is obtained. The defined need of the client will be develop into an appropriate design solution, with the aim of delivering approved production information. The aim is to secure full financial authority to proceed at the end of the Pre-Construction phase. The Construction phase commences only upon obtaining that authority. The Construction phase is concerned with the construction of the project. The Post-Construction phase commences on completion of the Construction phase. The process protocol continues into this phase, which aim to continually monitor and manage the maintenance needs of the constructed facility.

One of the objectives of the protocol is to improve efficiency and "to be in a better position to met the client's business needs" (TIME Research Institute 1997:1). This protocol could be applied with the same philosophy to the deconstruction process. A better understanding of the process and in satisfying the client's needs in the construction process is illuminated in the study. Those improvements are obtained through cost-effective visualisation techniques for designers and developers (Ormered and Aouad 1997:322). Ormered and Aouad developed the study based on 103 structured surveys to construction related professionals. Their views were obtained on the mediums currently being used in the construction industry; the effectiveness of these mediums to communicate information; and the applicability of visualisation techniques within their own organisation. The results highlight the need for further investigation and research into visualisation techniques, particularly in connection with the needs and understanding of construction industry clients.

The role of the architect in the demolition process and the importance of the preliminary survey are well demonstrated in a twenty-year-old work (Pledger 1977: 17) but still pertinent to the demolition process today. Topliss (1982: 39) reviewed the conventional techniques of demolition. He observed that during the planning stage a number of physical and environmental problems must be addressed. The solutions to these problems are normally presented as graphic information. Typically the information includes:

- The building plans, elevations and sections, to appropriate scales identifying clearly the main structure and characteristics of the building.

- Identification of the parts of the structure subject to the works, together with all the necessary information about the works.

- The dismantling sequence and the deconstruction methods to be adopted, scaffolding and other equipment.

- The requirements for recycling plant and selective materials collection.

- The responsibilities and technical restrictions deriving from the characteristics of the deconstruction work and the storage of materials to be reuse or recycled and any special safety and security conditions.

Topliss (1982) also argued that there was a need for further research into these techniques and for training and qualification of those involved in the work. The environmental agenda now requires the maximisation of the utilisation of the debris stream to be taken into account. This demands research into the quantitative and qualitative aspects of the waste stream; the sorting, grading and temporary storage of waste materials on site; reuse and recycling and reuse operations; plant characteristics and safety and security implications.

Technical Considerations Related to Different Phases

There are various methods of demolition. According to Holmes (1995: 297) the method used for the demolition of concrete depends on the type of concrete, its position in the structure and the purpose for which the cutting or breaking is being undertaken. The method of demolition chosen by the contractor should suit both location of site and type of structure. The methods include:

. Hand demolition. This involves the progressive demolition of a structure by operatives using hand tools.

. Swinging ball. This involves demolition by swinging a heavy steel ball suspended from jib of a crane.

. Wire ropes. This involves pulling the elements with wire ropes to demolish parts of a structure. Only steel ropes with a circumference of 38 mm or more should be used. The law requires that the ropes must be inspected frequently to ensure that their strength has not been impaired by use.

. Use of pushing arm. This method involves the use of a machine fitted with a pusher arm (normally hydraulic) which exerts a horizontal thrust.

Since this method is limited in its operation by height, the structure must be reduced to a suitable height by one of the other methods.

. Use of explosives. Demolition by explosives is used for a wide range of structures, including chimneys, cooling towers and complex structures that would be difficult to demolish by another method.

. Other methods include gas expansion buster, hydraulic buster, thermal reaction, thermic lance, drilling and sawing, purpose built shears, crushers, pulverisers, grapples and nibblers.

The Junta de Residus (1995a) stated that the particular conditions of each deconstruction method, the techniques and the sequence of the dismantling works should include:

. The removal of hazardous materials and contaminants.

. The removal of components with the objective of recovery in the best condition to facilitate their reuse.

. The segregation of materials integrated into components or placed in composite structural elements.

. The deconstruction of structural elements to maximise reuse or recycling.

. The selection of the best demolition technology to maximise the reuse and reutilization of materials.

. To adopt the appropriate technical approach to facilitate the selective collection of materials.

. To recycle the waste on site or in a recycling station close to the site is essential for sustainable practice.

. The adoption of technical approaches addressing the safety and welfare of the workers must be a priority.

Management of the Demolition Site. Waste Minimisation

The management of deconstruction work on site must be carefully planned to achieve waste minimisation. Pledger (1977) studied the UK experience dismantling and demolition industry and found that the work was carried out by four major types of business organisation, namely:

- General demolition contractors.

- Dismantling contractors who are associated with the scrap metal business.

- Specialist sub-contractors such as explosive engineers.

- Civil engineering contractors.

In addition many general builders undertake demolition work from time to time, but usually only on a very small scale.

The most efficient way to deal with waste is to minimise it, to prevent it occurring. This approach is essential at all stages of the process.

Decisions at earlier stages of the process influence the efficiency of waste minimisation at later stages of the deconstruction process (Pledger 1977). The choice of materials and construction technology at the design stage will have a profound effect on the efficiency of the deconstruction stage. Those decisions will influence the quantity of energy consumed, the cost of the process and the quality of material realised. It is important to control the quality and cost to enable the production of secondary aggregates that can compete on price and quality with new aggregates. To achieve these objectives the deconstruction work must be carried out in accordance with the recommendations set down in "From Drawing Board to Building Site – Working Conditions Quality Economic Performance" (EFILWC 1991). The recommendations are illustrated with examples demonstrating the close relationship between performance on site and marketing the products. Quality and conformity with customer's requirements delivered at the right price and time are the basis for successful marketing. To meet those criteria the deconstruction and debris trail must be well managed by properly trained personnel (Junta de Residus 1995a).

The Deconstruction Plan must develop a dismantling approach that must facilitate further use, at a low cost, of the materials released. It must identify, quantified and assess the quality the types of waste generated. The demolition methodology must assist the identification, separation and collection of the materials into containers. The materials should then be weighted and the quality assessed for reuse and recycling minimising the quantity going to landfill or incineration.

Fieldwork and the Quality of the Data

The quality of data obtainable on the debris correlates directly with the quality achieved by the deconstruction process. The quality of the process depends upon many factors, but the principal ones have been identified (Ferguson and Mitchell 1986). They were identified for the construction process but the ideas can also be applied to the demolition process and are as follows:

- Poor communication of design intention.

- Design difficult to build.

- Poor quality labour.

- Poor quality supervision.

- Complex and ineffective contract documentation.

- Unrealistic constraints on time and cost.

- Historical reasons: separation of design and construction.

The three main parties that should be involved in the deconstruction process are the client, the designer and the contractor. The designer must be involved in the deconstruction project (Junta de Residus 1995a). The designer needs to be involved in both the deconstruction process and the construction of the new building. The parties need to agree the quality levels and destinations of the elements of the debris trail before the project starts.

In summary, Ferguson and Mitchell (1986) states that it is important to observe and follow some rules:

- Survey and measure accurately.

- Keep occupiers fully informed.

- Consider reuses of items; when not possible, dispose of and delete any return from the contract sum.

- Allow for concealed decay and degradation

- Avoid damaging fabric and fittings which are to be retained

- Consider wholesale replacement of certain elements.

- Protect the fabric against further degradation with a view to reuse.

- Consider safety measures.

- Consider instability occurring from unbalance thrusts when members are removed from framed buildings.

- Walls – consider the stability of load-bearing and non-load-bearing walls and of party walls if roof or floors removed.

— Consider the nature of support of any cantilevered structure

- Consider the method of filling or protecting basements and void.

- Underground storage tanks – position, size, contents of tanks.

- Supplies and services. These may include:

. Drainage, gas, electricity, water, telephone, television or radio lines; hydraulic pressure mains; district heating mains.

.Benchmarks on buildings – which involves informing the Ordinance Survey Office.

Holmes (1995) also states that the client requires the demolition contractor to prepare a programme of proposed operations and to appoint a competent foreman to supervise the work. Particular attention should be given to the following:

- Licences for hoarding, fencing, lighting, etc.

- Scaffolding for accesses purposes.

- Closing of roads – special notices to Local Authority.

- Access to site – may need special protection; planning permission will be required if access leads directly on to a highway.

- Services – may require specialist treatment or diversion.

- Healthy and Safety – workmen must be protected at all times.

- Uncontrolled collapses – ascertain methods of support shoring etc.

The Main Constraints and the Future

The reuse and recycling of the construction and demolition waste stream is constrained by factors that arise from regulation, financial conditions and user requirements. It is necessary to develop specifications and other regulations for the use of secondary materials and to be able to meet those requirements with the components and materials. The quality needs to be guaranteed by the national authorities and laboratories. This is extremely important in order to guarantee the overall quality of materials, often from different sources. There is a need to change attitudes and behaviour in all the actors in the process. It is necessary to overcome psychological barriers in the construction industry so that the use of second market materials becomes an acceptable practice. There are various difficulties in the use of these materials (DoE 1994b).

These difficulties will be considered in the context of construction. There are areas where some action can be taken in order to encourage and create the proper conditions to improve the reuse and recycling of the construction and demolition waste stream (DoE 1995b). Firstly there is a need to improve the administrative framework governing recycling. Waste Disposal Plans and Waste Local Plans must define the main conditions to increase reuse and recycling giving the guidelines to achieve these objectives.

Secondly by giving encouragement to recycling as an activity and demonstrating the long term benefits to the environment. This requires planning for recycling and making recycling a more attractive operation. There is a need to develop Codes of Practice. There is a need by clients and government agencies to demonstrate a positive attitude by the incorporation of recycled materials in public sector contracts. Thirdly by creating attractive financing, such as subsidies, capital grants, levies on demolition, on primary aggregates and on landfills. The resulting saving of raw materials and energy leads the way to sustainable construction and the protection of nature.

A study by CERF (1996a: 8), giving an overview of construction industry preparation for the 21st century, states that there are some themes directed towards improving sustainable building and construction practices. They include:

1 – Advancing the application of global standards and performance criteria in infrastructures development.

2 – Utilising demonstrations to accelerate the adoption of innovation.

3 – Expanding and sharing the industry's knowledge base by taking advantage of new information technologies and systems.

4 – Streamlining the construction process by building partnerships, clarifying roles and responsibilities, and applying and integrated approach.

5 – Creating and implementing new analytical tools and methods necessary to develop, measure, monitor, and validate sustainable construction activities.

6 – Bringing understanding to industry, government and public to initiate and endorse changes needed for making sustainable development a reality.

7 – Defining sustainability operationally, i.e. in measurable terms that identify the means for its achievement.

These statements derived from a Delphi survey of the main actors in the construction process and constitute a set of guidelines towards a sustainable construction sector for the 21st century.

SECTION 2: QUANTITIES AND QUALITIES IN THE DEBRIS TRAIL

Introduction

This Section presents an overview of the quantitative and qualitative aspects of the debris trail. The typical composition of building construction and demolition wastes and reuse and recycling rates is discussed. The Portuguese construction waste stream is considered.

Debris trail

The composition of the construction debris trail determines the construction and demolition waste stream and is generated at the demolition site. It can occur as a result of the construction of buildings or other structures or may be produced from the demolition of old structures or parts of these structures. Included in the broad category of construction and demolition waste is waste generated by motorway re-paving, bridge building and demolition, and renovation and remodelling of buildings.

According to Stein (1993: 20.1- 20.3) in the USA, the construction and demolition waste stream may be a significant component of local and regional waste streams, often accounting for as much as 10% by weight of the total waste stream. Its disposal may tax an already stressed disposal system. This figure of 10% differs from the figures which have emerged from Europe and from other studies in the USA. European and other USA figures are 20% to 30% (Craven 1994) and also 50% to 60% in Europe (ICE 1995). The reasons for these discrepancies are not immediately apparent. They may be due to errors in measurement or differences in the construction technologies and therefore the weight of building materials included in the different studies. Differences in quantities of other wastes in the stream would also have an effect. This needs further research but is not taken further in this thesis. Table 5.1 gives the typical composition per ton of waste of construction and demolition waste in the USA.

Table 5.1 – Typical composition of building construction and demolition waste in the United States

Material	Mass content, %	Composition of C&D*, %	Volume, yd^3	Apparent density, lb/yd^3
Steel & Iron	1.57	2.73	0.05	1090
Copper	0.05	0.02	neg.	na
Lead	0.06	0.06	neg.	na
Aluminium	0.01	neg.	na	na
Concrete	63.33	53.75	0.90	1190
Brick & clay	15.01	na	na	na
Brick	Na++	21.21	0.35	1210
Wood	1964	22.01	1.10	400
Glass	0.33	0.22	neg.	na
Plastic	< 0.01	neg.	na	na
Total	100.	100.	2.4	830

C&D* composition based on 1 ton of waste
++ Apparent densities are calculated and rounded.
na - not available; neg- negligible.

Source: Stein 1993: 20.3.

Kaczmarski and Moore (1993: 6.1-6.35) undertook a study of processing strategies for construction and demolition waste in United States of America. They conclude that it is appropriate to categorise the waste stream into two main types: Type I and Type II.

Type I – Roadways and site conversion construction and demolition waste

This waste is typically classified as Type I if a large percentage of the waste stream (80 to 90 percent) consists of small number of fairly "clean" fractions of material (i.e. rubble, wood). A typical approximate composition of Type I construction and demolition waste by weight might be:

Rubble -

Concrete, asphalt	40 %
Soil, rock	20 %
Wood	30 %
Metals, plastic	10 %

Type II – Construction and Interior Demolition Waste

Type II construction and demolition waste is generated from the construction and demolition of urban structures (office buildings, stores, etc.). Type II waste differs from Type I waste in that the material is collected in "mixed" form (thoroughly mixed amounts of concrete, drywall, framing, ductwork, roofing, windows, corrugated, packaging, etc.). A typical approximate composition of Type II construction and demolition waste by volume, might be:

Rubble	25 %
Wood	33 %
Metals	20 %
Corrugated board	12 %
Other (carpets, residue, etc.)	10%

In Canada, Christensen (1994: 223-230) presented a summary of construction and demolition waste quantity estimates related to 1988. This is classified into three main groups: generated, diverted and disposal. Table 5.2 gives this information.

Table 5.2 – Summary of national construction and demolition waste quantities estimates 1988 in Canada

DESCRIPTION	GENERATED		DIVERTED		DISPOSED	
	(tonnes)	% of Total	(tonnes)	% of Generated	(tonnes)	% of Generated
Road & Bridge Related						
Asphalt	5,914,51	39,2	3,973,39	67,2	1,941,11	32,8
Concrete	3,589,87	23,8	2,427,60	67,6	1,162,26	32,4
Building Related						
Wood	1,858,86	12,3	77,61	4,2	1,781,24	95,8
Rubble	1,869,23	12,4	0(1)	0,0	1,867,23	100,0
Paper	357,43	2,4	0(1)	0,0	357,43	100,0
Gypsum	415,68	2,8	29,11	7,0	386,57	93,0
Building material	402,10	2,7	0(1)	0,0	402,10	100,0
Metal	373,13	2,5	0(1)	0,0	373,13	100,0
Other	312,75	2,1	0(1)	0,0	312,75	100,0
TOTAL	15,093,59	100,0	6,507,73	43,1	8,585,86	56,9

Source: Christensen 1994.

Waste minimisation is the first objective. In construction, with better management, it is possible to prevent some sources of waste. For example Rafael Gavilan and Leonhard Bernold in the USA (Craven 1994) present a study of the main causes of construction waste identified by various reports. Craven (1994) updated this study and the sources of construction and demolition wastes are presented in Table 5.3.

Table 5.3 - Sources and causes of construction wastes

Design	Procurement	Materials Handling	Operation	Residual	Other
Error in contract documents	Ordering error. Over-ordering/ under-ordering/etc	Damaged during transportation to site/on site	Error by tradesperson or labourer	Conversion waste from cutting uneconomical shapes	Criminal waste due to damage or theft
Contract documents incomplete at commencem. of construction	Suppliers error	Inappropriate Storage leading to damage or deterioration	Equipment malfunction	Offcuts from cutting materials to length	Lack of on site materials control and waste management plans
			Inclement weather		

(fast-track) Changes to design			Accidents Damage caused by subsequent trades Use of incorrect material requiring replacement	Overmixing of materials for wet trades due to a lack of knowledge of requirements Waste from application process Packaging	

Source: Craven 1994:91.

Craven (1994:97) developed a methodology based on the principal that it necessary to emphasis the prevention of waste creation and to design buildings for deconstruction. Their proposal was based on the concern for the sustainable agenda and also the fact that 20% to 30% by weight of waste going to landfill is from construction and demolition activity.

SECTION 3: CONSTRUCTION AND DEMOLITION WASTE IN EUROPEAN COUNTRIES

Introduction

This section concerns the source composition and the increase in the amount of construction and demolition waste produced in European countries. It also discussses the destination of the material. The Portuguese position is presented together with the efforts that have been made to improve reuse and recycling of this waste stream.

RILEM recommends (De Pauw, Vynck and Desmyter 1994:389), that aggregates deriving from the construction and demolition waste stream should be classified into three categories, i.e.:

. Type a - aggregate, which originate primarily from masonry rubble.

. Type b - aggregates, which originate primarily from concrete.

. Type c - aggregates, which consist of, recycled aggregates and natural aggregates

The technical committee RILEM TC 121 – DRG "Demolition and Reuse Guidance" developed and published the results of the study with recomendationsin the document entitled "Concrete with Recycled Aggregates". It is being discussed in the CEN TC 154 ad hoc group for recycled aggregates with a view to giving it the status of a European standard (De Paw, Vynck and Desmyter 1994:389). The need of specifications, consistent classification criteria and further research in construction and demolition waste stream are also highlighted.

At European level, a EU working group (Morgan and Argus 1995) has identified the following components in the construction and demolition waste stream:

– Aluminium products

- Asbestos products.

- Asphalt.

- Clay, Bricks and Tiles.

- Concrete.

- Glass.

- Glasswool, stone wood and slag wool.

- Gypsum based construction materials.

- Iron and Steel.

- Plastics.

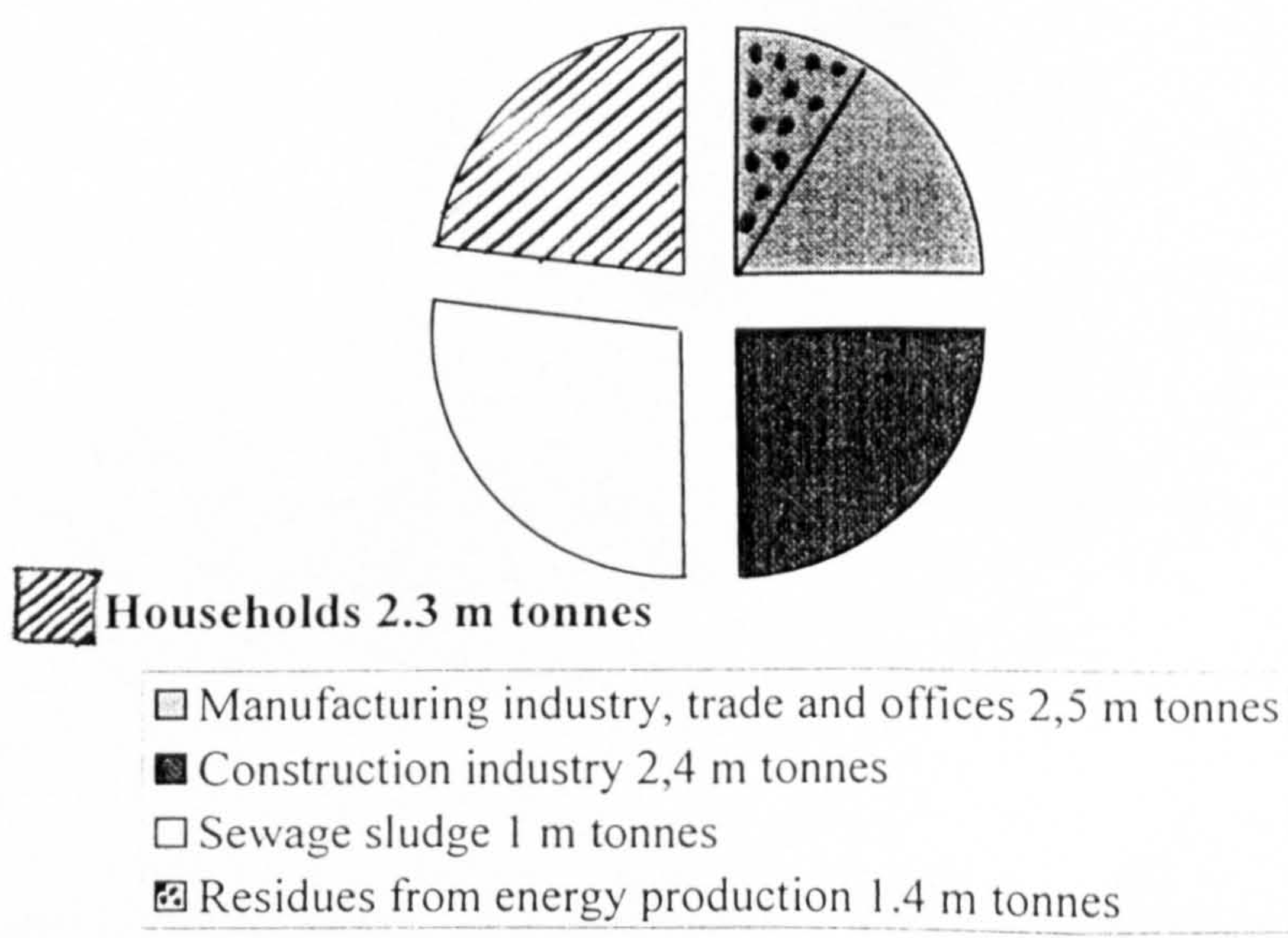
- Plastic Foam Insulation.

- Textiles.

The information was collected by questionnaires issued to Project Group members in 1993, and updated by questionnaires issued in January and February 1995. The data received did not contain significant information about the quantities of these components.

Information is available on the total amount of waste produced in Denmark and also on their construction and demolition waste stream. The total waste production in Denmark by source in 1993 (MEE 1996) is shown in Figure 5.3.

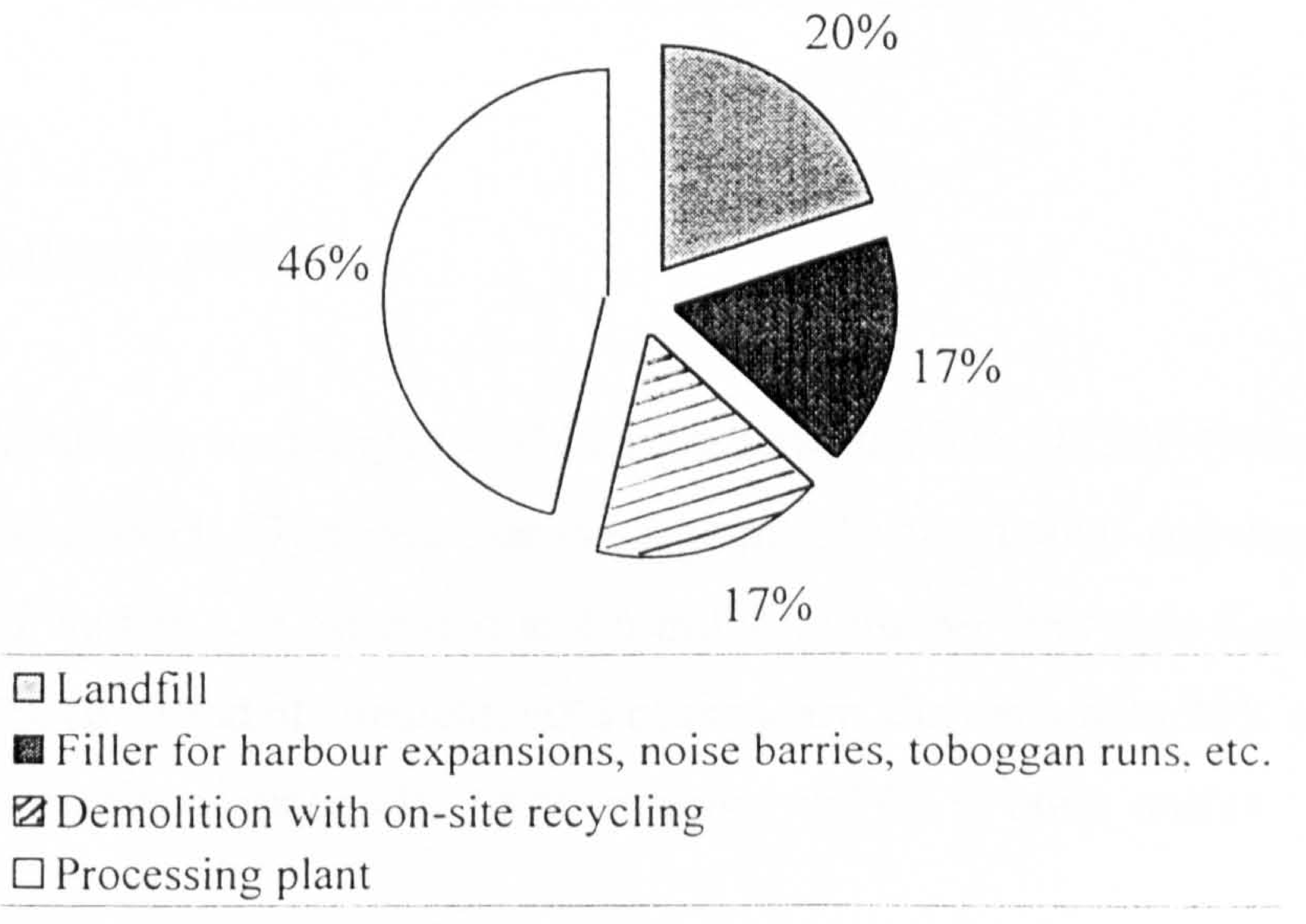
Figure 5.3 – Waste production in Denmark broken down by source (1993: 9.6 m tonnes)



Source: MEE 1996.

The recycling of construction and demolition waste in Denmark increased from around 10 % in 1985 to around 80 % in 1993. Selective residential demolition trials have shown it possible to recycle up to around 90 % (MEE 1996). This waste stream represents 25 % of the total waste production in the country. The high recycling rate for construction and demolition waste has been achieved through the introduction of duty on waste that is not recycled. Financial support has been granted to research and development projects, which document recycling opportunities and establish systems for collection and processing recyclable waste. It is the responsibility of the contractor to dispose of any waste and that disposal must be in accordance with the applicable regulations. To achieve these goals, there are mobile and stationary crushing plants and a positive attitude to reuse and recycling. The disposal of construction and demolition wastes in 1993 is presented in Figure 5.4.

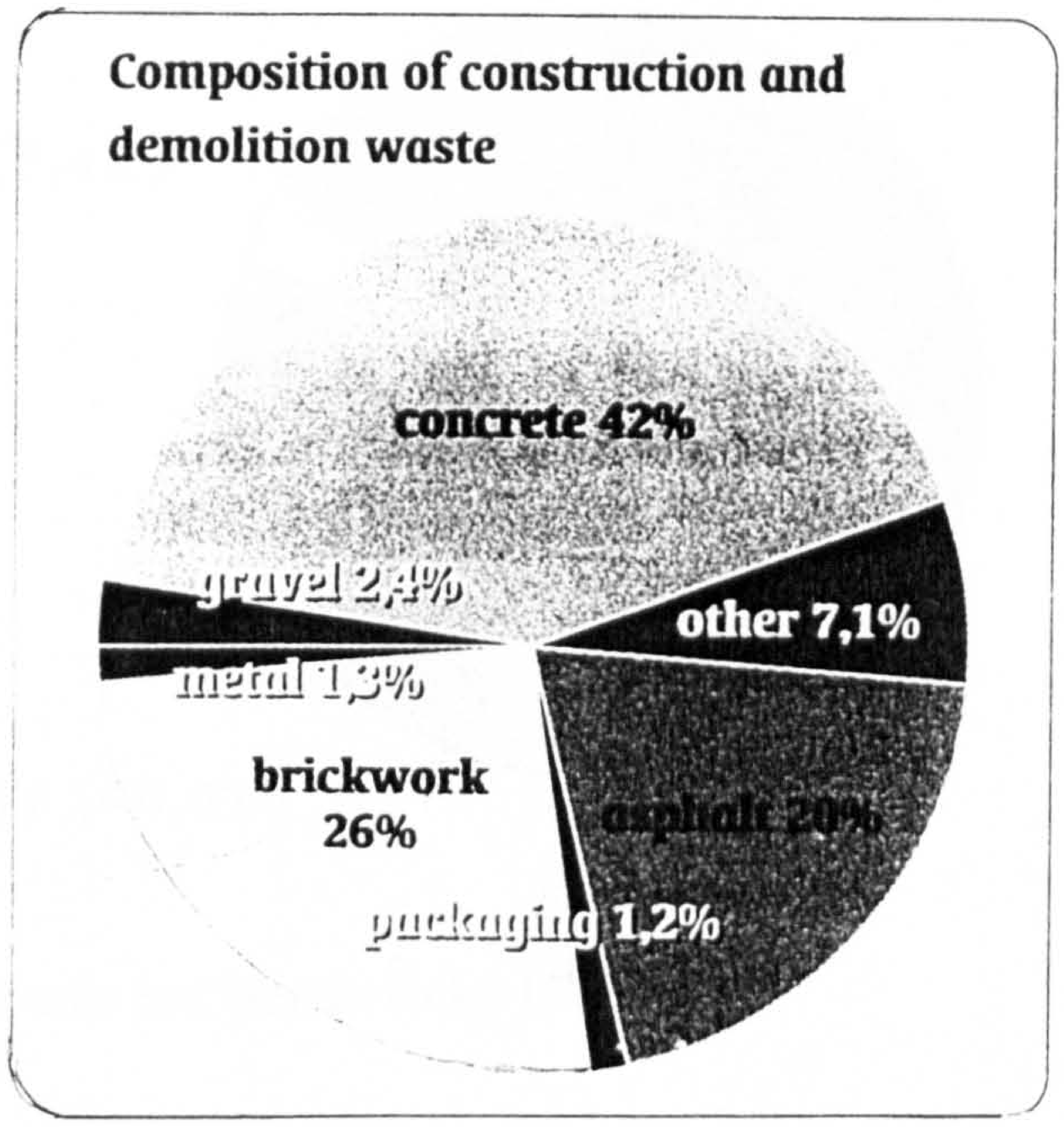
Figure 5.4 - Disposal of Construction waste in Denmark in the year 1993



Source: MEE 1996.

In the Netherlands, the construction and demolition waste stream (MHSPE 1997) was 13 million tons a year in 1995. Due to a large number of measures developed under an Implementation Plan for Construction and Demolition waste (MHSPE 1993) the recycling of construction and demolition waste has increased rapidly since 1992 to around 90%. Figure 5.5 shows the composition of construction and demolition waste in the Netherlands.

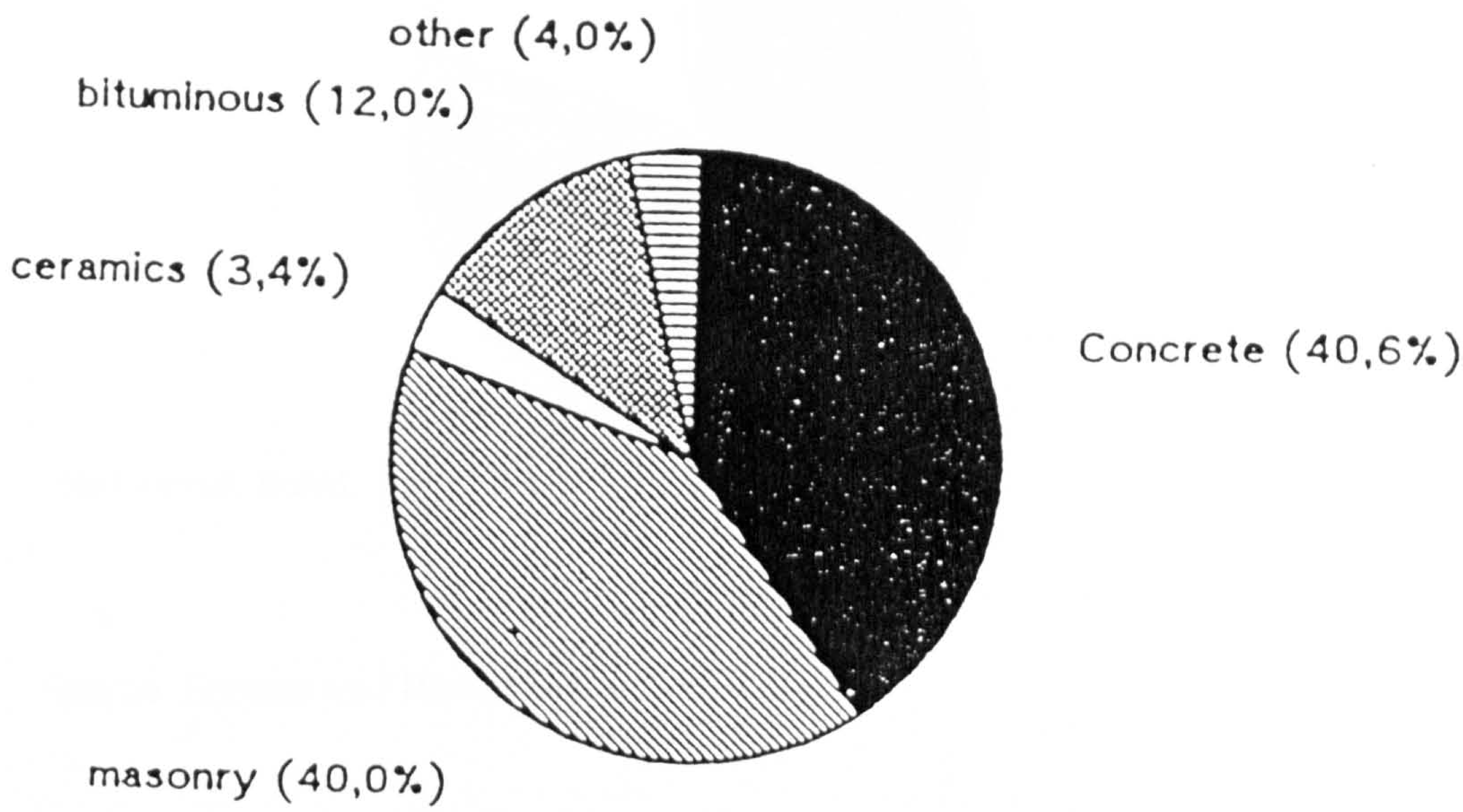
Figure 5.5 – Netherlands composition of construction and demolition waste



Source: MHSPE 1997:13:1.

A study by the Belgian Building Research Institute (BBRI) (Simons and Henderieckx 1993: 27) stated that the amount of construction and demolition waste in Flanders was estimated at 4.6 million tons per year (see Figure 5.6). Some 40% consisted of concrete, 40% of masonry; the remaining 20% consistd of 12 % bituminous materials, 3.4 % ceramics and 4.6 % other wastes.

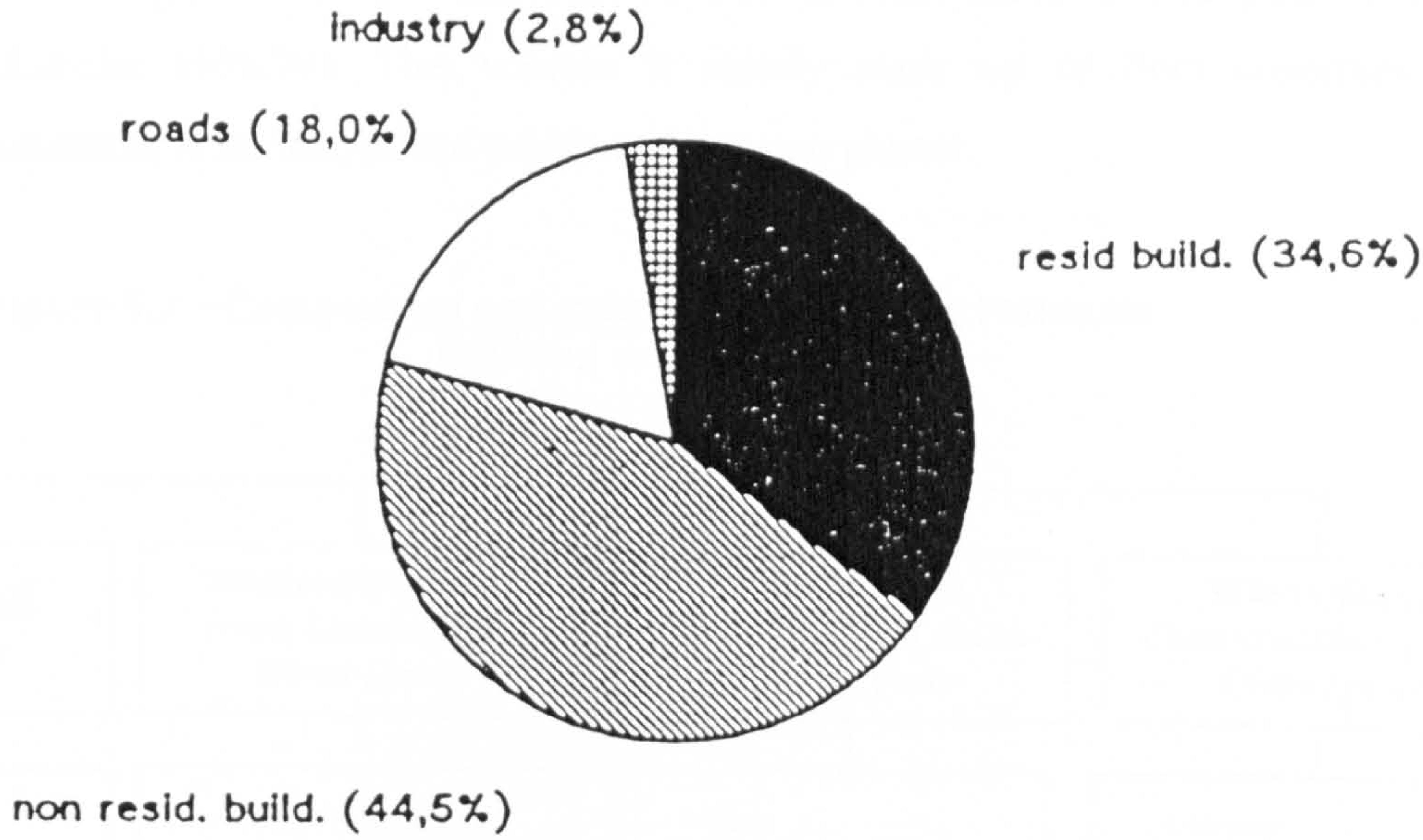
Figure 5.6 – Flanders, construction and demolition waste average composition



Source: Simons and Henderieckx 1993:27.

In this study Simons and Henderieckx identified a number of sources of the wastes, including buildings (residential and others), roads and building material manufacturing companies (see Figure 5.7). Kohler (1996) observed that in Germany the average composition and quantities of building residuals in the total waste stream was more than 70 % per cent by weight and around 60 % by volume. The total annual waste was nearly 400 million tons and the weight of "old" building materials was 285 million tons per year.

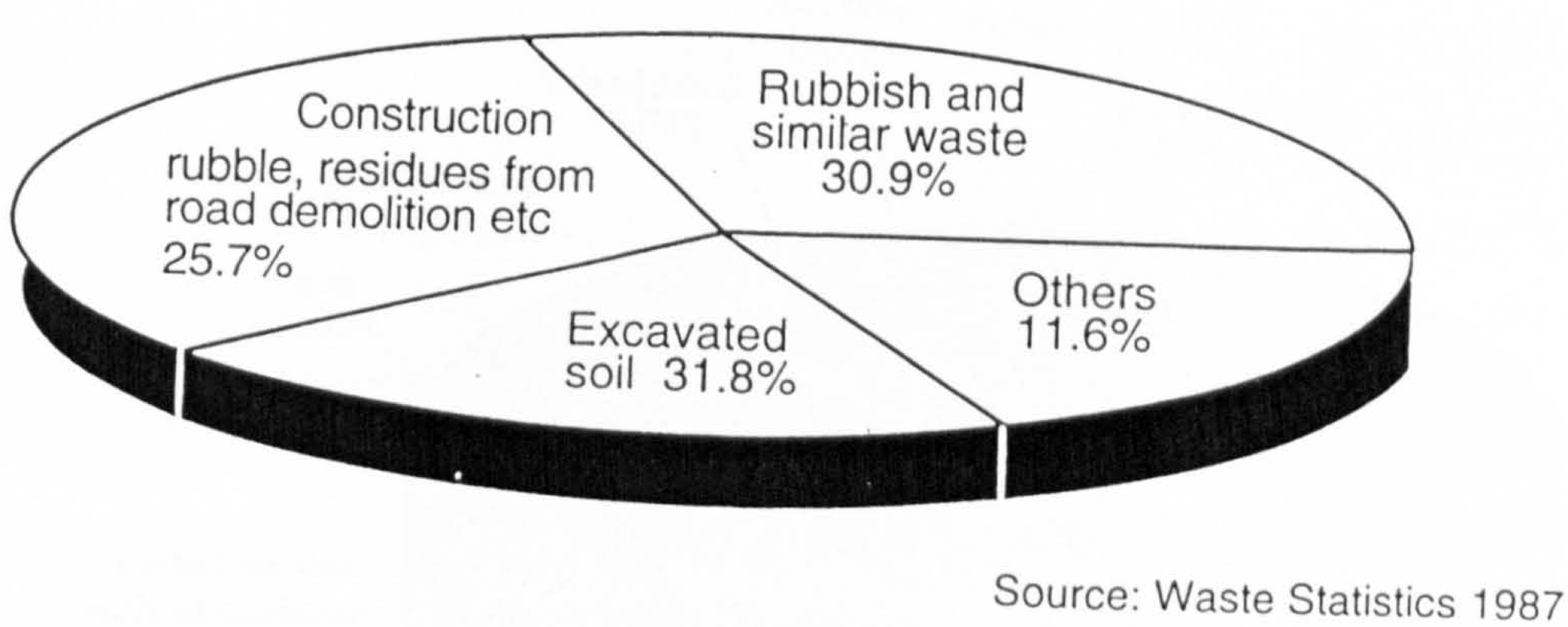
Figure 5.7 – Sources of the wastes at Flanders region



Source: Simons and Henderieckx 1993:27.

A study of the German situation (Koheler 1996) entitled "From down cycling to recycling building waste in processing complexes" presents the proportionate waste volume in the recent past in public landfills in Germany (see Figure 5.8).

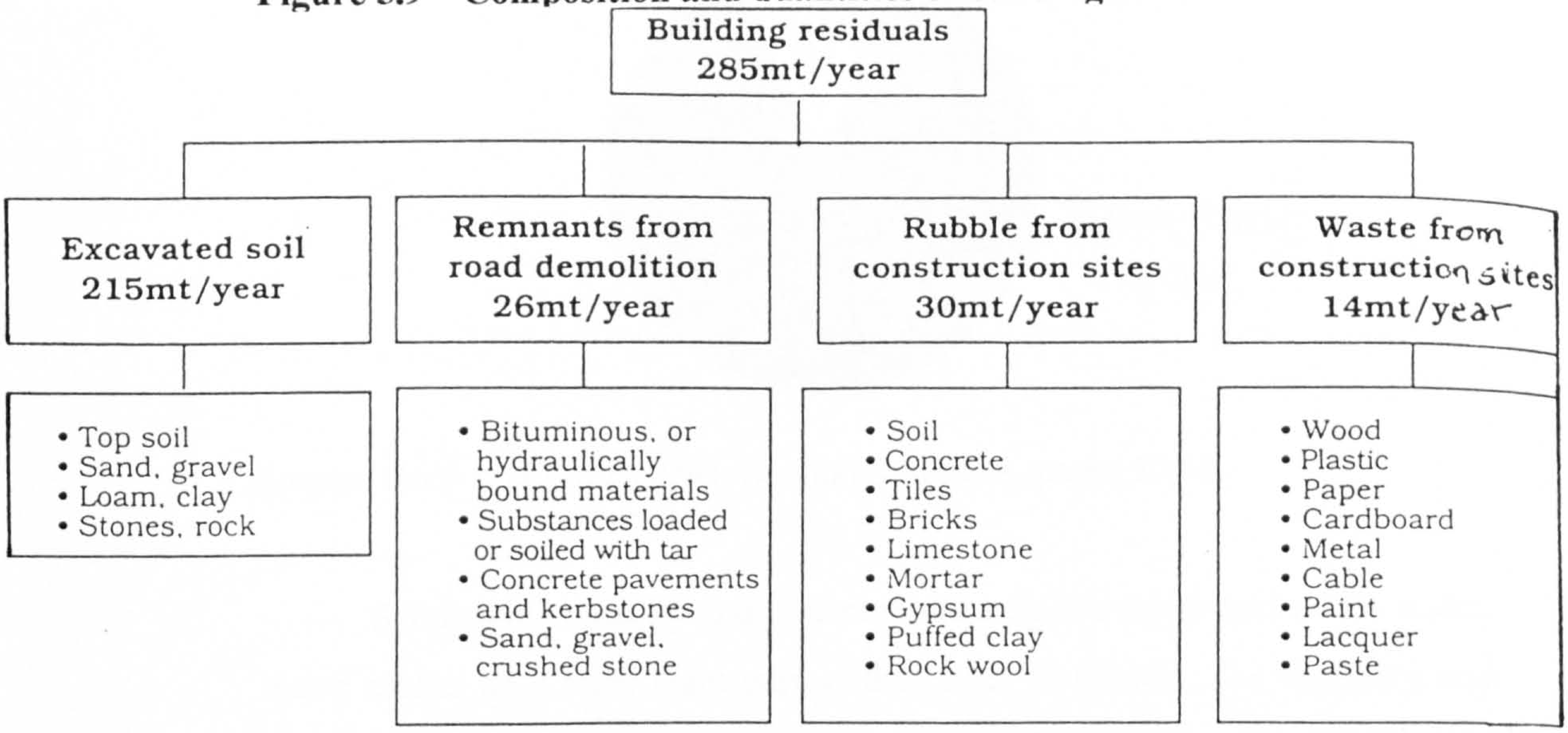
Figure 5.8 – Proportionate waste volume on public German landfills. Waste Statistics 1987



Source: Koehler 1996:77.

Figure 5.9 shows that only 6%, about 65 tons, had to be send to landfills (Koheler 1996:78). This volume is mainly made up of floor coverings, insulating materials, mixed rubble and gypsum plaster.

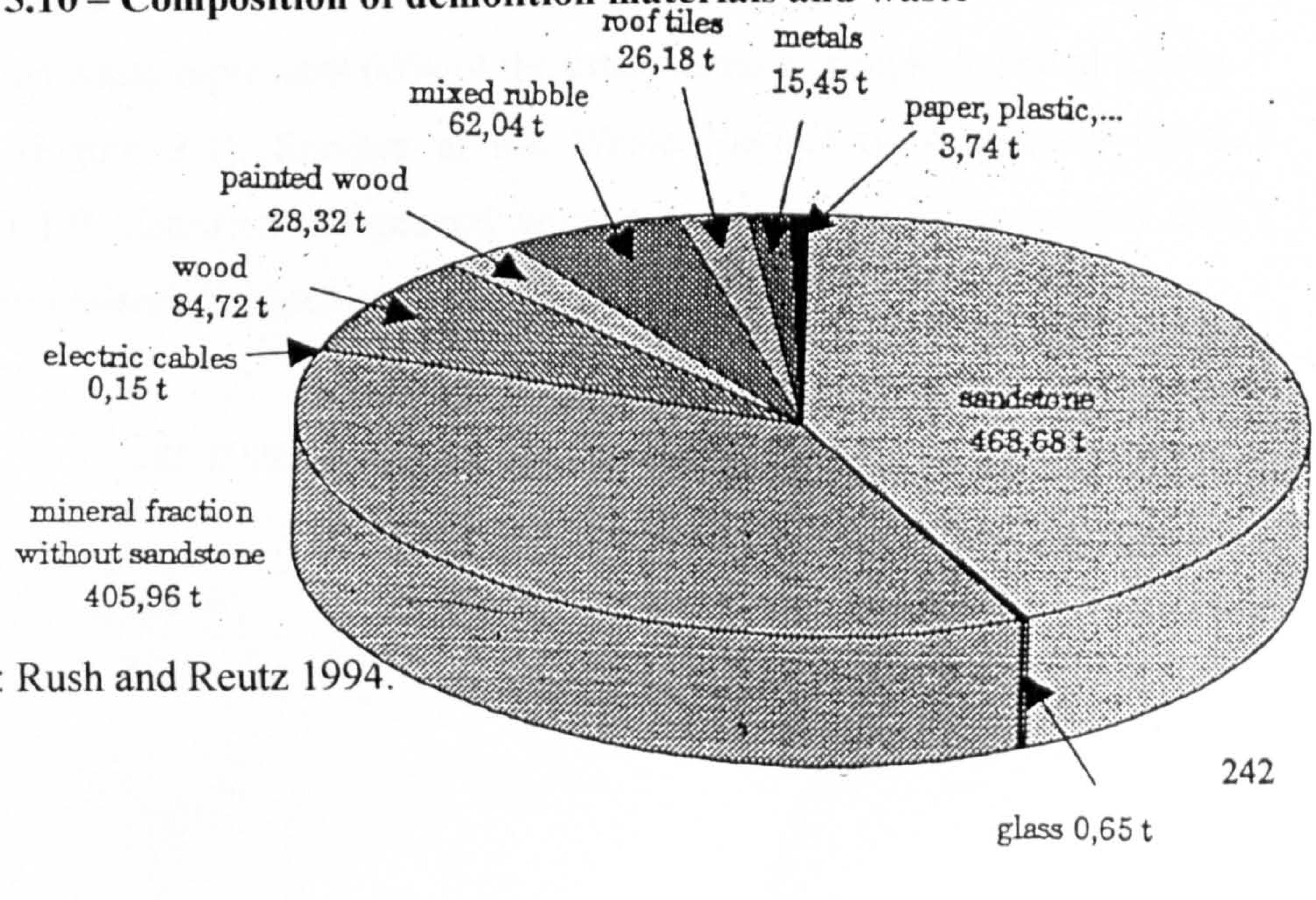
Figure 5.9 – Composition and quantities of building residuals



Source: Koheler 1996:78.

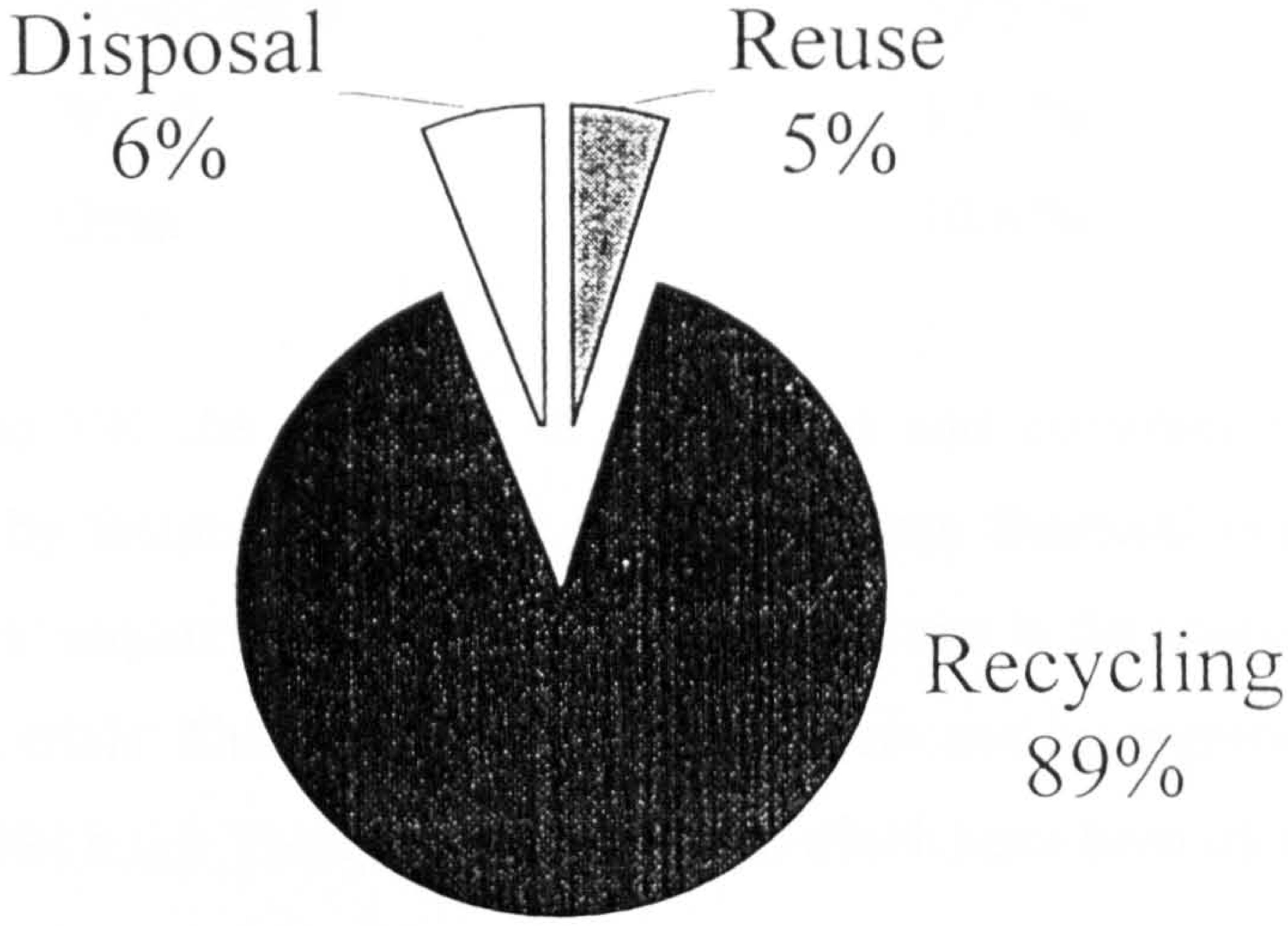
The results from a pilot study of a dismantling and selective demolition project in the Black Forest, Germany (Ruch and Reutz 1994) showed the composition of demolition materials and waste after dismantling (see Figure 5.10 and Figure 5.11).

Figure 5.10 – Composition of demolition materials and waste



Source: Rush and Reutz 1994.

Fig. 5.11 - Reuse and recycling rates dismantled materials



Source: Ruch and Reutz 1994: Session Materials, paper 10:10.

Sandstone, masonry and concrete make up the major part of the waste. Wood makes up a significant part of the lesser materials. The recycling and reuse rate of 94% by weight of the materials released from the pilot project building was very high and demonstrated the potential for reducing the debris trail to landfill.

According to ICE/AME (1991:2), construction and demolition wastes and general industrial/commercial wastes form 80 % of the national tonnage of waste disposed to landfill in the UK. The study "Managing and Mimizing Waste Construction" published by the ICE (1995) shows that building and excavation waste represents 60% of the total wastes arising in a typical county landfill (Figure 1.4). Surveys at six Waste Regulatory Authorities (DoE 1995b:D 17) identified the general volume percentages of construction and demolition materials which are being landfilled in the UK.

Component material	% estimate by volume
Brick	8.3 %
Concrete	10.2 %

Bituminous Materials	5.3 %
Soil/Clay	44.4 %
Sand/Gravel	17.5 %
Wood	3.3 %
Other	10.6 %

In the UK the recycling of demolition and construction wastes is constrained by factors which arise from regulation, financial conditions and product users' requirements. The overriding constraint is the unacceptability of recycled materials. The products are seen as waste and by implication second rate (DoE 1994 b:ix). The specific constraints which have been identified are:

- Statutory control – recycling and recycled products require permission and or licences under several different regulations.

- Waste Plans – waste disposal plans in the past have often been concerned only with the recycling of household waste. Without a requirement for facilities to recycle demolition and construction wastes, local waste plans are unlikely to identify potential sites or the criteria to be applied when assessing applications for their development.

- Planning applications – although local authorities may support recycling in their policy documents, in practice it can prove difficult to obtain planning permission as the advantages of recycling are often deemed to be outweighed by local environmental concerns.

- Feedstock – the quality of feedstock is poor, often being mixed and potentially contaminated. Little attention is paid to segregation at the site of arising.

- Lack of investment in processing – in an industry with low financial return and little long term security, investment in processing plant is often kept to a minimum.

- Quality control – there is limited control of the quality of both feedstock and products. Sources of materials are generally not inspected and considerable mixing occurs at the processing site. Whilst this may not be of concern for low level products, any contamination which occurred in a potential high quality end product would not be traceable.

- Environmental concerns – the potential pollution effect on ground water and watercourses from industrial sources is of increasing concern to monitoring organisations. These organisations are beginning to resist the use of recycled materials in fills, unless it can be demonstrated that they will not have a polluting effect.

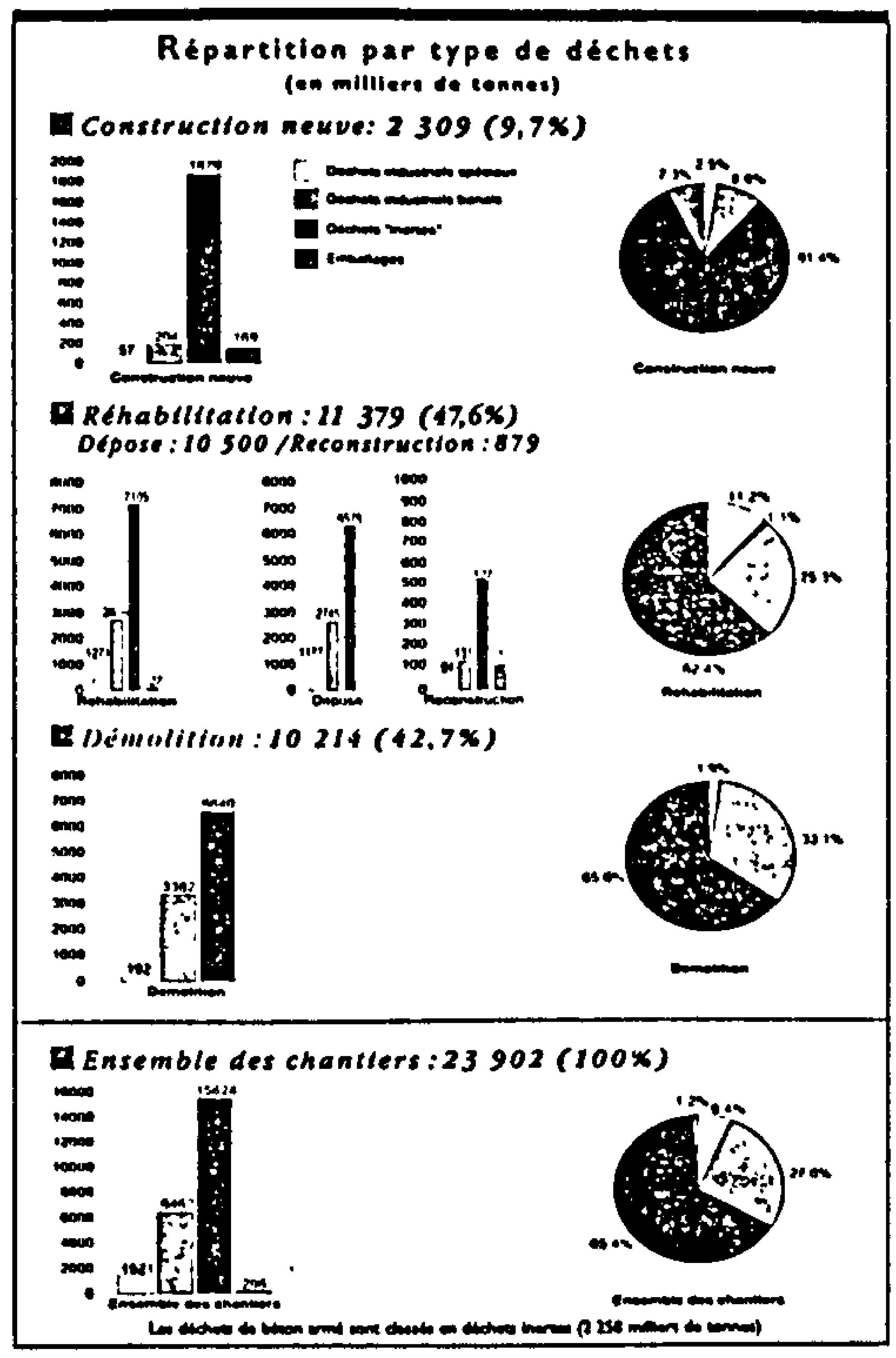
- Market constraints – the ready availability of cheap established primary aggregates severely restricts the market for recycled products. Unless a use for recycled products is available locally, there is no incentive for contractors and operators to process and stockpile materials.

- Standards and specifications – although there is scope for the use of secondary and recycled materials within the main current specifications, their use is rarely encouraged. There is no specific standard for recycled aggregates against which producers can market a material of assured quality.

- Liability – with available supplies of low cost and proven primary aggregates, engineers are not prepared to accept any potential risk inherent in specifying a secondary material which may come from a variety of sources with differing physical and chemical properties.

A recent study from ADEME (1998) demonstrates the construction and demolition waste stream from building in France. It shows the source and quantities of the waste stream classified as from new construction, rehabilitation and demolition. The results are presented in Figure 5.12.

Figure 5.12 – Construction and demolition waste in France



Source: ADEME 1998:3.

The study revealed the details of the composition of the waste produced by each of the sources. The methodology of the study will be used to obtain the data needed to construct the model which is the focus of this thesis.

This section has reviewed the source, composition and the increase in the amount of construction and demolition waste produced in the European countries. The bulk of the waste by weight was masonry and concrete. Those materials also made up a significant percentage of the landfill materials. Research projects across Europe revealed a range of materials in the construction and demolition waste trail but there was no common classification system. Valuable materials were being recycled but there was a need to create the conditions for the recycling of the masonry and concrete materials that made up the bulk of the debris trail.

Construction and Demolition Waste in Portugal

Portugal has an absence of data, which has affected and limited the first steps towards a national strategy. In these circumstances it has been impossible characterise the quality and quantity of the materials in the Portuguese construction and demolition waste stream. Since 1996, this waste stream has been referred to as Municipal Solid Waste (MA/INR 1997:91) and some steps have been taken to study it.

Procesl (1997) made the first study of the subject in Portugal. The main objective was to get data for analysis to provide information about the siting of fixed construction and demolition waste stream recycling plant in the Lisbon area. The enormous problems of this waste stream are centred on the absence of potential landfil sites in the Lisbon area and in the surrounding local authority areas. Transportation costs and the environmental impacts of trucks are additional problems. There is a necessity to define a management model for this problem. It is a pilot study focussed on the Lisbon area and does not represent the country as a whole. There are significant differences in characteristics of the waste stream between the developed coastal area and the inland rural countryside.

The criteria for the selection of cases to be studies were based on work undertaken by Cabrita, Aguiar and Appleton (1993). They classified building types in Lisbon according to construction materials and construction technology, size and . The clasification of the type of buildings adopted from Crabrita, Aguiar and Appleton (1993) were:

- Type 1includes buildings constructed before the big earthquake in Portugal in 1755.

- Type 2 includes buildings of stone and brick masonry with a timber framework and with a maximum of 3 floors and constructed between 1755 and the 1875.

- Type 3 includes buildings with stone masonry and timber framework but up to 6 floors high.

- Type 4 includes concrete framed buildings with stone and brick masonry, built in this century.

The Procesl study further classified developments with similar characteristics of construction or type of building defined as homogenous areas. These areas were defined by studying the master plans of the city, by making an historic and morphologic analysis of the zones of the city and from National Statistics Census (INE 1998).

It was also necessary to define the type of construction works such as refurbishment, rehabilitation or demolition being undertaken (INE 1998).

The characteristics were limited by the lack of available information needed to develop a more finely tuned classification. Bureaucratic and organisational difficulties limited the number of cases studied. The main difficulty was insufficient information on demolition activity. The late application to the municipality by the contractors for permits to carry out the demolition work hindered the research team in observing and recording the works. It resulted in the team being unable to carry out the necessary surveys prior to the work starting. It is essential to have all the permits issued some days prior to the beginning of any demolition work in site. When that does not occur it severely limits the quantity and quality of the data that can be obtained. It significantly restricts the analysis. The cases studied studied consisted of:

Type of construction work	Number of cases
Refurbishment	4
Rehabilitation	2
Demolition	1

Figure 5.13 presents the figures obtained from the sample.

Figure 5.13 – Construction and demolition waste stream characteristic in Lisbon area. Results from the Pilot Study

TYPE OF MATERIAL	COMPOSITION OF WASTES													
	SAMPLE A		SAMPLE B		SAMPLE C		SAMPLE D		SAMPLE E		SAMPLE F		SAMPLE G	
	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%	kg	%
BRICK MASONRY	60,9	1,46	144,5	1,55	530,0	12,38	61,0	1,74	2,3	0,03	722,5	23,31	33,4	0,83
STONE MASONRY	0,0	0,00	119,6	1,28	120,5	2,82	0,0	0,00	1,0	0,01	0,0	0,00	0,0	0,00
CONCRETE	162,1	3,90	529,8	5,68	1 036,7	24,22	59,8	1,71	35,8	0,49	0,0	0,00	72,4	1,80
CERAMIC TILES	46,5	1,12	0,0	0,00	55,6	1,30	17,3	0,49	0,0	0,00	0,0	0,00	19,2	0,48
PAPER/CARDBOARD	2,5	0,06	0,0	0,00	11,5	0,27	1,9	0,05	2,0	0,03	0,0	0,00	0,8	0,02
PLASTIC	0,3	0,01	1,0	0,01	2,5	0,06	3,6	0,10	7,9	0,11	2,2	0,07	0,5	0,01
TIMBER	56,0	1,35	5,5	0,06	19,1	0,45	9,9	0,28	11,5	0,16	111,7	3,60	10,2	0,25
FERROUS METALS	2,0	0,05	27,2	0,29	1,0	0,02	128,0	3,66	7,0	0,10	27,5	0,89	1,0	0,02
NON FERROUS METALS	1,0	0,02	12,5	0,13	4,0	0,09	0,0	0,00	0,1	0,00	0,0	0,00	0,5	0,01
OTHER NON INERTS	1,0	0,02	105,1	1,13	1,1	0,03	0,0	0,00	1,5	0,02	0,0	0,00	0,0	0,00
OTHER INERTS	3 827,7	92;01	8 374,8	89,86	2 498,0	58,36	3 218,5	91,96	7 290,9	99,06	2 236,1	72,13	3 882,1	96,57
TOTAL OF INERTS	4 097,2	98,49	9 168,7	98,38	4 240,8	99,08	3 356,6	95,90	7 330,0	99,59	2 958,6	95,44	4 007,1	99,68
TOTAL OF N/INERTS	62,8	1,51	151,3	1,62	39,2	0,92	143,4	4,10	30,0	0,41	141,4	4,56	13,0	0,32
TOTAL	4 160,0	100,00	9 320,0	100,00	4 280,0	100,00	3 500,0	100,00	7 360,0	100,00	3 100,0	100,00	4 020,0	100,00

Source: Procesl 1997:86.

The combined data from the seven cases give the average composition by weight as:

. brick masonry.. 4.3%
. stone masonry.. 0.7 %

. concrete .... 5.3 %

. ceramic tiles .... 0.4 %

. paper and cardboard.. 0.1%

. plastic.. 0.1 %

. timber.. 0.6 %

. ferrous metals .... 0.5 %

. non ferrous metals...0.1%

. other inert...87.7 %

. total of non inert...1.6%

The characteristics of each of the contractors involved in the study were similar. It prevented a comparative analysis of the nature of the deconstruction process with respect to different manpower management approaches, qualification and training of the operatives, equipment and technologies used and other variables. The study (Procesl 1997) is completed but the political response necessary to move forward is still awaited.

The study produced some qualitative and quantitative data that is used to support the case study in this research. It will give insights into the deconstruction process and the construction and demolition waste stream in Portugal. These are described and discussed in Chapter 8.

SECTION 4: HAZARDOUS MATERIALS IN BUILDING CONSTRUCTION

Introduction

This Section discusses the questions related to hazardous materials in building construction such as asbestos and contaminants contained in timber, metals and plastics. Soil contamination and risks to human health are also discussed.

Hazardous materials and products used in the construction of buildings are a threat to public health and must be avoided in sustainable construction. In the tri-dimensional sustainable construction model (Kibbert 1994a) referred to chapter 3 there are three axes. These axes are, the principles, the resources and the phases. The avoidance of hazardous materials and products is a principle to observe in sustainable construction. This Section also deals with soil contamination from the use of hazardous materials and products and considers the remediation action appropriate to each situation. According to Curwell and March (1986), there are a number of materials used in the construction industry that could be hazardous to public health. They can be classified in the following groups:

. Asbestos and other materials

. Man made mineral fibres

. Metals

. Lead in building materials

. Plastic and toxic chemicals

In the demolition process, it is common to find asbestos, painted and preserved timber, with lead composites and other heavy metals. The deconstruction process must be undertaken with care in order to protect the workers' health and to prevent the contamination of the waste stream with such debris.

Asbestos and other fibres

In the construction industry asbestos is the material which needs most care and attention. In existing buildings there are different kinds of asbestos with different hazardous levels. The three types of asbestos (Curwell and March 1986) are:

- White asbestos or chrysotile which can be found incorporated within other materials in different concentrations in finishing treatments and in thermal, acoustic and pipe insulation.

- Brown asbestos or Amosite, a trade name for asbestiform cummingtonite – grunerite, may be found incorporated in laminated boards as well as in pipe insulation.

- Blue asbestos or crocidolite may be found in more or less pure form as fire insulation in heating systems. It may be also found mixed with other forms of asbestos in board or in asbestos cement mixed with chrysolite.

In the USA the Environmental Protection Agency has used its authority to publish regulations for asbestos. In the mid 1960s, an American Cancer Society study showed an increased incidence of asbestosis and mesothelioma type cancer in workers who were exposed to asbestos insulation materials (Wentz 1989: 72). It is a serious problem in the United States. Many buildings constructed throughout the 1960's and early 1970's contain significant quantities of asbestos-based fireproofing and insulating material. Building demolition, remodelling and through normal degradation these fibres are being released into the internal environment. Many organisations are considering asbestos removal or various abatement programmes in an attempt to protect their employees and the public at large. At each site a comprehensive survey for the presence of asbestos and the assessment of the potential hazards must be undertaken before an asbestos removal program can begin.

The exposure to concentrations of airborne asbestos dust by workers demolishing asbestos cement clad buildings is cause for concern elsewhere. In Australia (Brown 1988 344-350) research has been undertaken into the measurement asbestos dust concentrations and the protection of workers' health. The same concern caused the Japanese (Motohashi, Yusa and Takahashi 1988: 351- 357) to develop techniques to protect workers from the hazards of asbestos whilst dismantling buildings. The USEPA proposal to ban asbestos in buildings (USEPA 1986) prompted the work in Japan. An additional problem identified is the method of final disposal or treatment of the asbestos materials and components after removal. The Construction Engineering Research Laboratories in the USA (CREL) (CREL 1995) recommends plasma heat treatment to destroy materials containing asbestos. This matches USEPA requirements that recognised the Plasma Arc Concept as a viable technique for the destruction of asbestos fibres and renders asbestos harmless.

Following the publication of the European Council Directive (EC 1987) and the International Workers Organisation (IWO) Convention nº 162 and Recommendation nº172 Portugal adopted specific legislation on asbestos in order to protect workers' health. These are the Decreto-Lei nº 284/89 from the 28th August 1989 and the Portaria nº 1057/89 from the 7 December 1989. This legislation restricts workers' levels of exposure to asbestos, and requires specialist contractors to remove asbestos.

The project for the decontamination of the Berlaymont 2000 building in Brussels demonstrated the difficulty of asbestos removal. The Berlaymont complex was built between 1963 and 1967 and leased to the by the Belgian government. The European Institutions occupied it from 1967 to 1991. It was the offices of the European and the Commission's administrative departments. Nearly 30 years after it was built the building was no longer suitable for the needs of the European Commission. The European Commission moved from the Berlaymont in 1991 and transferred its departments to several buildings elsewhere in Brussels (Anon 1995).

Asbestos was discovered in the Berlaymont building but it was assumed that the situation was not dangerous so long as the asbestos remained "fixed" (Anon 1995). Only asbestos dust released into the air and inhaled has a carcinogenic effect. However, such a release of asbestos dust could take place as a result of a fire or other accident or during maintenance work on the building. The building was empty and asbestos removal would also have been necessary if the building was to be demolished. The demolition would have removed a key building from Brussels' urban landscape and it is a symbol of Europe in the heart of Brussels (Rodrigues 1998). A decision was therefore taken to preserve the Berlaymont as a symbol of the beginning of the European Union. Work on the building was to proceed in two stages:

1 - Asbestos removal, followed by

2 - Renovation

The asbestos removal work started in 1995 in accordance with a strictly controlled project programme and methodology. The size of the building (200,000 m2) and the quantity of asbestos to be removed estimated at approximately 1.300 tonnes of flocked asbestos made it the largest operation of asbestos remove undertaken in Europe. The aim was to render the asbestos safe without the release of asbestos fibres into the atmosphere. There were two ways to achieve that aim (Anon 1995):

- By leaving the asbestos where it was and to enclose the asbestos fibres and materials in "encapsulating" envelopes, or

- By removing the asbestos flocks and materials containing asbestos from the building.

The second method was chosen for the Berlaymont building, in order to make it possible to complete renovate the building. This method of asbestos removal is simple in theory. In practice, it is difficult and requires the observance of many detailed precautions to protect the health of the workers and of those living near the building. Five months into the asbestos removal project it was evident that there was a high level of fibre escaping into the atmosphere outside building. This led the Brussels City Council, under pressure of public opinion, to stop the works and to seal the building (Rodrigues 1998). The building remains sealed until a resolution to the problem can be found.

In Portugal, a similar problem has arisen over the removal of some asbestos sheets from the Economy Faculty of the University of Porto. The staff, students and professors require the asbestos sheets to be removed on health grounds. The Asbestos Industry Production Association (AIPA) does not agree. Fibre concentration analysis has shown that the asbestos fibre concentration is significantly lower than the threshold set down in the European Directive, and the Portuguese legislation deriving from it. The problems experienced at the Berlaymont are pertinent to the debate. The problem at the University of Porto is not yet resolved. Research undertaken in Portugal (Cabeçadas and Magalhães 1981:9) showed that there are more than 3000 uses for asbestos and two thirds of them are construction industry applications. The Portuguese AIPA is forecasting an increase of 10 % in asbestos production (Anon 1998). Whilst this increase in production occurs the safe installation, use and removal of the material in building remains unresolved.

Cellulose fibres and some other fibres such as contained in calcium silicate board and some phosphogypsum could be also harmful to human health. Man made mineral fibres have been commonly classified into four groups:

- mineral fibre formed into mineral wools

- Ceramic fibres produced from aluminium silicate minerals

- Synthetic mineral fibres

- Naturally occurring fibres that are generally crystalline.

The use and expose to these materials is the subject of research to discover their effects on human health.

Timber, Metals and Plastic

Timber is a benign material but wood preservatives, surface treatments, and some kinds of paints are toxic (Curwel and March 1986). The application and removal of these materials can present a threat to human health. A key cause for concern is that it may be difficult to recognise that the material is present in timber that forms part of the debris trail. Inappropriate disposal could release the toxic materials into the environment.

Metals have many applications in building construction. Their use in building has occurred over many centuries. Metals used in buildings include iron, steel, aluminium plain and anodised, zinc, copper and lead. The need to take care with lead is addressed by Curwell and March (1986). Lead was used in water service pipes and many of those pipes still exist. Initially lead solder was used to connect copper piping in drinking water services it. The lead solder has now been superseded by lead free solder but many installations still exist with lead solder. Lead is still used in roofing details and as a roof covering but is now generally avoided in building materials. The presence of lead in water and air pollution and in paints has cumulative effect on human health (Curwell and March 1986). Cadmium is of concern when used in water supply systems. It too is forbidden in water supply facilities. Paints containing cadmium or lead must also be avoided.

Plastics and toxic chemicals are used in many materials and components incorporated into buildings. They include polyvinyl chloride (PVC), polystyrenes for electrical fittings, polyurethane, polyethylene and others. All of them have different kinds of toxicity that will be released into the environment if disposed of inappropriately.

Pollution prevention practices and strategies for demolition waste have been studied at several institutions. The Center for Hazardous Materials Research (CHMR) at the University of Pittsburgh Trust stressed the need for a hazard inventory or waste audit to be undertaken before demolition activity. The audit was necessary to determine the nature and extend of contaminants presents (CHMR 1997). A report from EEA/WHO (1996) focussed on environment and health gives an overview of the main issues in the field in Europe. There was a significant emphasis on suspended particles in air pollution that identified the problems and presented the consequences for human health. It set down some goals and strategies to mitigate the problem.

Soil contamination is a threat to the environment and to human health and it is necessary to develop measures to mitigate these impacts. Site investigation is always the first step in the process of decontamination or removal (Sellers 1999:1). The current state of the three European Programmes related to contaminated land and sites was discussed at a workshop in 1997. The areas covered by the workshop included recycling technologies, treatment of wastes, the restoration of contaminated sites and life cycle assessment (INETI/DGXII/DI/ECPEC 1997). NICOLE is a three-year programme addressing industrial contaminated land in Europe and commenced in February 1996. The objectives of this network is:

- To provide a European network for dissemination and exchange of scientific and technological knowledge and ideas relating to all aspects of contaminated land (soil and groundwater) arising from industrial activities.

- To promote co-ordinated, multidisciplinary collaborative research that will enable European manufacturing and processing industry to efficiently and cost-effectively identify, assess and manage contaminated sites.

- To inform planners of National and European research programmes of priorities for future research and to improve the synergy and co-ordination of research being carried out in EU programmes and other initiatives at European and National levels (Veen 1997:325).

The CARACAS project is of 30 months duration and also commenced in February 1996. It is a study to ascertain the concerted actions on risk assessment for contaminated sites in the EU. The objectives of the programme are.

- The identification and compilation of relevant R&D projects and scientific approaches for risk assessment on contaminated sites in Europe and to summarise the risk assessment methodologies used in European countries.

- The evaluation of the state-of-the art of risk assessment for contaminated sites in Europe.

- Recommendations on scientific priorities for future research and development programmes as well as the establishment of an information network on risk assessment issues in Europe.

- Establishment of an information network on risk assessment issues in Europe and the co-operation with major international initiatives on contaminated land (Kasamas 1997:357).

The third project concerns a contaminated land rehabilitation network for environmental technologies (CLARINET:377) (Schamann 1997). It started in June 1998 and will run for 36 months. The primary objective of this project is to make technical recommendations for the rehabilitation of contaminated sites based on current scientific knowledge. This is a co-operative study involving scientists, authorities and industry, the major interest groups engaged with contaminated land issues.

Sometimes during the construction of a building, or more probably from the processes carried on within it after construction, the soil becomes contaminated. Contamination of land and groundwater is the results of many processes. Industrial activities are responsible for the principal impacts but construction activity also has some impact. Buildings on contaminated sites are demolished and the problems associated with contamination and remediation of the land are intrinsically linked to that activity.

Soil Contamination and Remediation

This Section discusses the main issues related to soil contamination. It also addresses remediation action for buildings that contain hazardous materials as the problems are linked. According to Diputació de Barcelona (1987:19), soil contamination can be classified in endogenous or exogenous contamination. Endogenous soil contamination concerns normal soil constituents present in a non-natural form or concentration. For example the majority of microelements present in soil could be toxic to plants if they were to be absorbed in rates not compatible with the plant physiology. Exogenous soil contamination is that resulting from human activity such as energy production, industrial and agricultural activities and waste management.

The British BRE studies on the performance and durability of construction materials (Paul 1994) in aggressive soil conditions stresses the importance of prior site investigation and chemical analysis. The National Rivers Authority on it Contaminated Land and the Water Environment expressed similar views (NRA 1994).

Experience demonstrates that emphasis must be placed on preventing site contamination. The best planning is the application of intelligent foresight to protect the environment and the character and future of the community (Smith 1979). The planning process commences with the identification of the problem. The plan must control the action by prescribing the problem solving activity. Planning represents the conscious organisation of human activities to serve human needs. Better planning can be accomplished by greater integration of the separate components of a problem into a broader and more coherent framework. That framework depends upon the nature of the site situation and planning process. Buskirk (1986: 238- 254) presented an example of the process:

"- Identify problems and specifiy objectives.

- Design, study, and compile an inventory of conditions and resources.

- Analyse data and formulate plans and polices.

- Evaluate alternative plans and policies and select the best alternative.

- Implement the plan or policy and continuously monitor the implementation."

Buskirk's example gives an overview of the general mission of planning. It also illuminates the scope of planning, the approach, and processes. The general mission of planning for site remediation is to appropriately clean up chemically contaminated sites.

Hazardous waste planning creates plans, policies, or programmes that can be classified into four major types of planning (Soesilo and Wilson 1997). They are:

- Hazardous waste management planning.

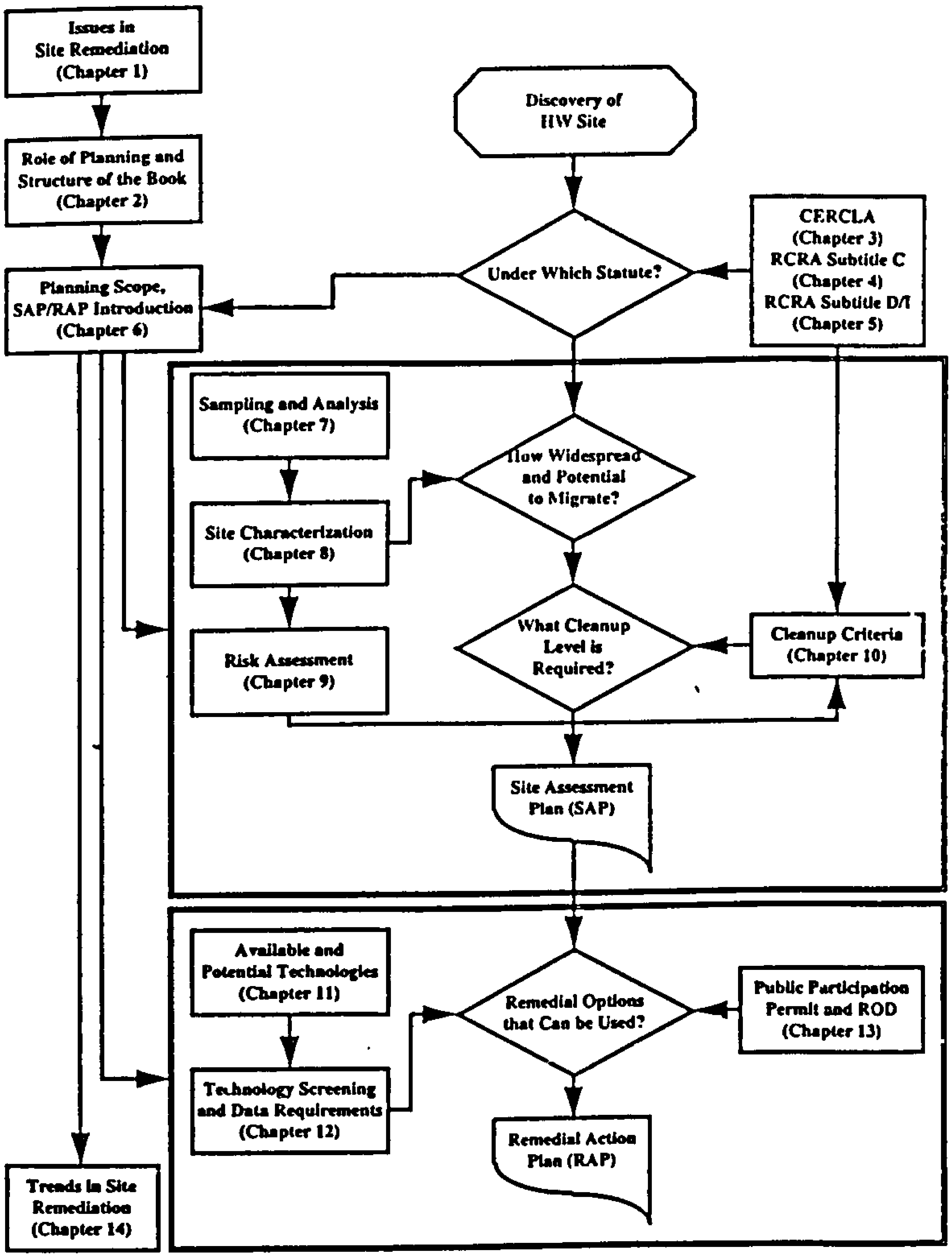
- Site correction and remediation.

- Emergency response and hazard management.

- Citizen participation planning.

There are three major types of site remediation technologies. They are biological, physical\chemical and thermal treatments. Within each group of remediation technologies there are in situ and ex situ technologies. For each technology, the applicability to soil or groundwater contamination is indicated. The framework is shown in Figure 5.14 (Soesilo and Wilson 1997:316). The figure also shows measurement technology and other less popular technologies such as containment and monitoring.

Fig. 5.14 – Site remediation framework



Source: Soesilo and Wilson 1997: Fig. 2.1:25.

A publication from CIRIA (CIRIA 1996b) reflects on recent changes in this area of concern and the interactions with building construction. It concludes by discussing the best practices to avoid soil contamination.

In Portugal, the most significant experience related to soil remediation was in the development of the Parque EXPO'98 area (EXPO'98 1998). An area of 330 hectares in eastern Lisbon was chosen for Parque Expo'98 that was the last world exhibition of this century. The site had been occupied by oil companies and was in an advance state of decay. This was due to the type of industries on the site and the way the plant had been constructed and operated. The lack of specific Portuguese environmental legislation allowed the conditions to develop. The environmental strategy for the development of Parque Expo'98 involved a number of schemes intended to remedy specific situations of environmental degradation on the site. Decontamination work was based on information gathered and compiled in specially devised diagnostic surveys. Soil with a high hydrocarbon content were excavated and removed to the Beirolas Landfill where it was contained. The Beirolas Landfill was sealed and reused for a garden park (EXPO'98 1998). During the development works a mobile water treatment station was installed to clean the underground water to recycle the extracted oil products. The site is now a permanent exhibition and recreation centre and a commercial and residential area.

The economics of the process are an integral part of the data needed to inform a decision. The economic perspective should be present in the feasibility studies together with environmental, technical, social, institutional and political considerations. It is the focus of the next Section.

SECTION 5: THE ECONOMICS OF THE DECONSTRUCTION PROCESS

Economy and the environmental are fundamental linked. They are not separate entities and come together in the discipline of environmental economics (Turner 1993). The selection of appropriate integrated management approaches to Municipal Solid Waste (MSW) is of concern to the EU. The EU commissioned Coopers & Lybrand and the Centre for Social and Economic Research on the Global Environmental (CSERGE) to study the question (EC 1996d:52). A cost-benefit analysis was carried out to assess the feasibility and cost minimisation of the integrated management of Municipal Solid Waste (MSW). It has implications for the deconstruction process. Some conclusions flow directly from the waste management hierarchy of prevention, reuse, recycling, recovery and final disposal. The conclusions were:

- The assessment of the total net economic costs of the different Municipal Solid Waste management options broadly supports the existing waste management hierarchy.

- Policy should be geared to promoting further source reduction and recycling.

- Economic instruments alone are potentially useful but will be insufficient; there will be a continuing need for regulation.

- The promotion of recycling and source reduction is taken to be a key policy objective.

- Charges on raw materials, energy or products (e.g. packaging) would be most economically efficient. Special attention should be given to their impact on European Union competitiveness.

Some of the resistance to the adoption of secondary materials is based upon economic arguments. This is a broad issue where those involved in the discussion tend to see the economic case from the perspective of a local cost centre. It is only by taking an inclusive view of the economics and with integrated management will it be possible to resolve the problems of using reused and recycled materials, especially in the the construction industry. From an economic perspective the problem begins with the necessity to examine the costs and benefits of handling and disposing construction and demolition wastes. There is considerable difficulty in obtaining reliable data on costs of each stage of the processing and handling the wastes. The information is scarce and ERL (1980:45) have given some reasons for the lack of reliable economic information. The ERL reasons are:

- Many operators do not have detailed cost data and, as removing and disposing of the waste will often form only a relatively small part of the value of a demolition/construction contract. "Rule of thumb" or simple estimating rules are used to cost this part of the operation and are common in the industry.

- Handling and disposal costs are highly location specific, such that large variations in costs occur not only between countries in the European Union but also between different localities within a country.

- Different contractors will have incurred capital costs at different times and under varying financial conditions, and operate under different circumstances in respect, for example, taxes, labour and regulations. In most cases, it was not possible for us to determine precisely how cost figures quoted were calculated (many being in the nature of rough estimates).

- Certain activities, for example, separating out valuable and easily accessible materials on-site and applying excavation wastes as a fill or for site landscaping are normally carried out as a matter of course, with clear economic advantages to the contractor. Cost data on such activities do not exist. It is not seen as essential for making management decisions (ERL 1980:46).

Examining the benefits of recycling produced similar reasons for the lack of data. From the contractor's point of view the recovery of a portion of waste may confer two kinds of financial benefits:

- Possible revenues from the sale of the recovered materials.

- A saving in waste transport and disposal costs (ERL 1980:46).

ERL (1980:46) give the reasons for the considerable difficulties in quantifying costs and financial benefits of waste recovery as:

- For most materials there is no sufficiently regular market to establish firm prices.

- Availability of competitively priced natural aggregate and size of local market will be main determining factors.

- The prices of scrap materials, which can always find an outlet, fluctuate considerably over time and between locations in the European Union.

- Transport distances and disposal charges to contractor are highly specific.

The costs and benefits of the deconstruction are both direct and indirect. Direct cost and benefits can be identified as tangible and affect the cash flow of waste contractors and processors. The indirect cost and benefits might not normally inform the decisions of the contractors and processors but relate to the overall social and economic context of the community (ERL 1980:47). The main factors, which could affect recycling solutions, are:

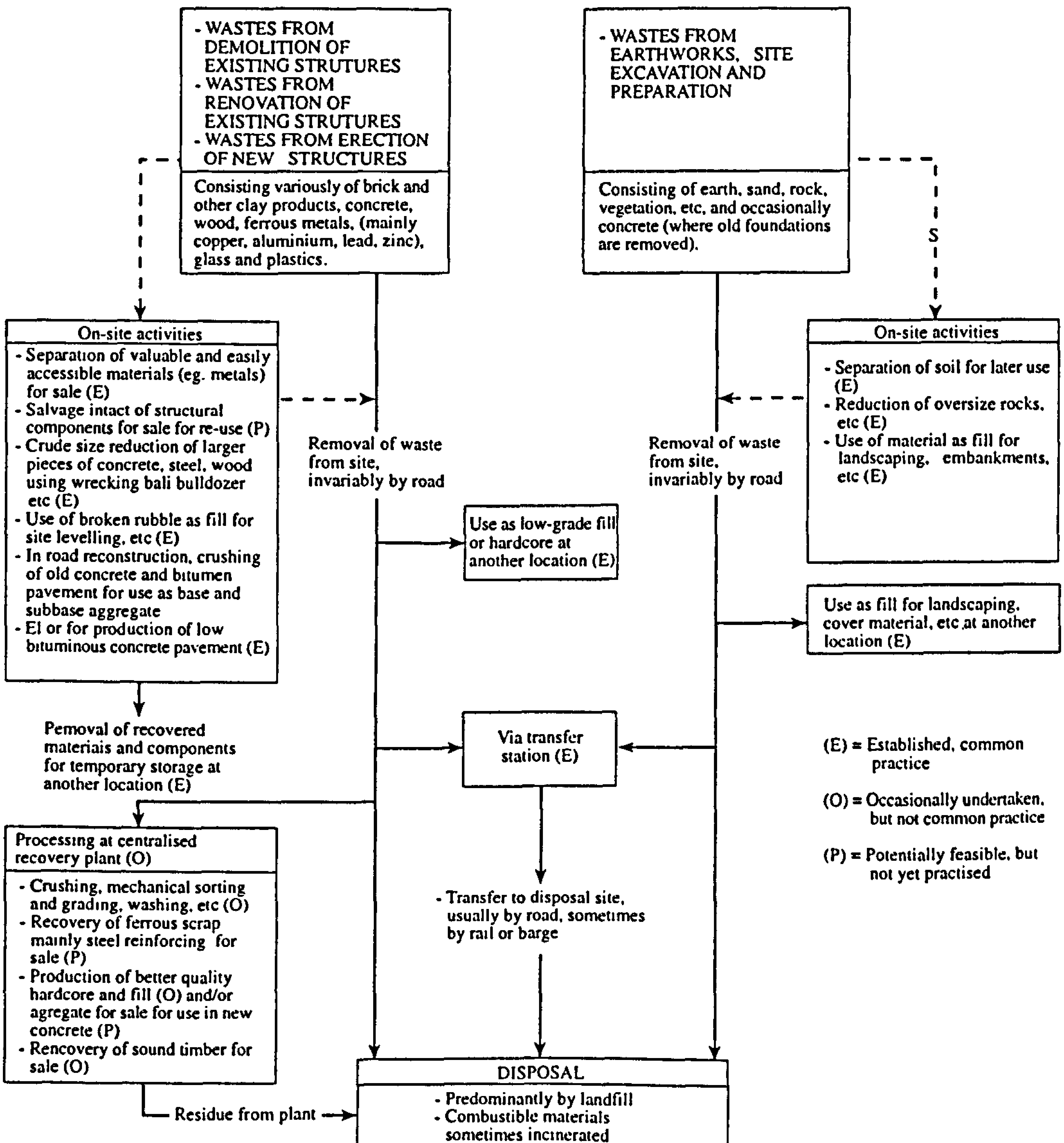
- The effects on the environment and amenity of transporting and disposing of theses wastes.

- Conversely, the impact of recovery on environmental pollution and amenity destruction (both from reducing the amount of waste requiring transport and disposal, and reducing the need to extract virgin raw materials).

- The potential value of this material to the community in terms of savings in imports and intrinsically scarce resources including energy.

Figure 5.15 shows the main possible options for handling demolition and construction wastes:

Figure 5.15 - Flow diagram to show the main possible options for handling demolition and construction wastes



Source: ERL 1980:49.

The handling of demolition and construction wastes typically involve three distinct kinds of activity, namely (ERL 1980:48):

- The separation and processing of waste materials and components at the point where these arise (i.e. at the demolition or construction site itself).
- The loading of separated materials and waste into road vehicles and their transport (occasionally via a transfer station) to a storage depot for the recovery of materials, to a recovered materials dealer/user, or to a disposal site.

- The final disposal of unwanted waste.

In considering the economics of waste handling, it is therefore important to realise that decisions affecting handling are rarely totally under the control of the demolition or construction contractor and the several separate organisations are often involved at different stages (ERL 1990:50).

McHugh (1990: 29), points out that the US EPA Pollution Prevention Manual (USEPA 1990a) shows the economics of waste minimisation from a global viewpoint and contains details of the construction and demolition waste stream.

A study undertaken in the USA entitled "Developing a Cost Effective Plan" (Showalter, Mills and Jarman 1998) demonstrates the necessity of adopting waste management plans by contractors and shows the potential economic cost saving, as well as the environmental benefits avoiding pollution and soil contamination. Contractors will soon be faced with a choice of reducing the waste they generate or becoming less economically competitive. Factors that help to achieve recyclability, or the increase in waste recycling practices, are waste markets, high tipping fees, and high raw material extraction costs. Showalter, Mills and Jarman (1998) also stresses that a waste management plan should incorporate four fundamental Sections:

1-Assessment of the material wastes on a particularly project.

2-Development of standards and alternative waste disposal methods.

3-Calculation of the economic impact of the disposal methods available.

4-A section to summarise, implement and update waste management technique chosen for a project.

Cooper (1994) stressed the economics of recycling and cost-effective systems of waste reclamation in a comprehensive review of four countries. It must be stressed that economic advantages and political priorities to increase market share is seen as compatible with sustainable development.

A recent study from the European Union (Symonds et al. 1999:69) addresses construction and demolition waste management practices and their economics impacts. The researcher observed that there was no clear evidence to suggest that any individual practices had become inappropriate, and in general they endorse them. The recommendations made cover:

1 – Waste managenment (29 recommendations)

2- Pre and post construction activities (9 recommendations)

3-Construction and demolition site management (9 recommendations)

4– Implementation of the strategy (3 recommendations), and

5 – Monitoring of, and follow up to the strategy (4 recommendations)

SUMMARY

This Chapter has dealt with the deconstruction process and its principal characteristics and interrelationship with the construction and demolition waste stream. It has presented a quantitative and qualitative characterisation of the construction and demolition waste stream. It has discussed the practical aspects and difficulties in carrying out fieldwork and the quality of data obtained. Consideration is given to the phases of the deconstruction process. The characterisation of the debris trail and the quality and quantities of the materials in the debris trail are also discussed. The state of the art in construction waste management in European counties is compared with the state of infancy in Portugal. The presence of hazardous material in the waste stream is noted and the necessity for developing audit surveys and risk assessments is stressed. Hazardous materials such as asbestos are discussed. Soil contamination and remediation are considered in relation to the construction and demolition process. The necessity to adopt cleaner technologies in manufacturing and other processes is stressed. The Chapter concludes by considering the economic influences in addressing the management and valorisation of waste.

CHAPTER 6:

RESEARCH METHODOLOGIES

"Man is by nature a questions asked and an answer seeker"

(Ross 1974)

INTRODUCTION

This Chapter discusses research methodologies their characteristics and application to the research questions posed. The initial decisions concern the focus of the research and the title of the study. Once established there is a need to select the appropriate design for the study (Edwards and Talbot 1996). It is clear that researchers have individual approaches to research questions. The individuality creates different foci on different aspects of the research subject and the use of different research methods to approach the research questions (Barnes 1992). Section 1 addresses the strategy and methodologies for developing research design. It sets down the research questions and discusses approaches to research design, the components and criteria for judging the quality of the research design are also addressed. Section 2 discusses the qualitative and quantitative methodologies and focuses on case study methodology, systems thinking and soft systems methodology and system dynamics methodology. Section 3 overviews the interrelationship between system dynamics and soft systems methodologies. Section 4 is focused on the development of the practical case studies. Section 5 concerns data collection.

The Research Question

The focus of this research is to understand the nature of the deconstruction process and the relationship with the characteristics of the demolition debris trail. The knowledge gained will be used to model the construction and demolition debris trail. The objective of the model is to demonstrate and the range and quantity of the materials in the debris trail. That information will provide decision support for the development of a Portuguese strategy for the sustainable management of construction and demolition waste. There are six principal research questions addressed:

1 - How can obsolete buildings be deconstructed to contribute to sustainable construction objectives?

2 - How can the study of the debris trail contribute towards the maximum recovery of resources?

3 - What are the characteristics of the construction and demolition waste stream/debris trail?

4 - To what extent can a dynamic modelling tool for estimating the range and quantity of the materials in the debris trail be developed to better illustrate the relationship between the characteristics of materials in the waste stream and the nature of the deconstruction process?

5 - To what extent can the insights given by the construction and demolition sub system of that model be used to improve the deconstruction process and waste stream resource recovery to fulfil the objectives of sustainable construction?

6 - To what extent can the insights given by the model be used to modify the behaviour of all participants involved in implementing an integrated strategy for sustainable construction?

SECTION 1: RESEARCH DESIGN

Research has been defined as a process of seeking, by way of methodological enquiry, solutions to problems and to add to one's own body of knowledge and that of others through the discovery of significant insights (Herbert 1993). The Oxford Dictionary (1995) defines research as the act of searching, closely or carefully for a specific thing or person. An investigator discovers some fact by the carefully study of a subject, a course of scientific inquiry. Orna and Stevans (1995) have a wider definition which leads to the designing of maps of research territory, highlighting the essential aspects of the research process, in particular taking the "before", "during", and "after" activities into account.

Whilst there are many definitions of research the common thread is that research is essentially an investigation, a recording and an analysis of evidence for the purpose of advancing knowledge. Philosophically, a basic human desire has been to add to human knowledge. As Ross (1974: 3) put it "...man is by nature a question asker and an answer seeker". Sometimes the search for answers, is motivated by the sheer necessity of solving an immediate problem, at other times it is motivated by a higher, philosophical, need to understand human existence and meaning in the world.

Smith, Thorpe and Lowe (1995) present three main classifications of research: pure, applied and action research. The key feature of pure research is that it is intended to lead to theoretical developments, in one of three forms: as discovery, invention or reflection. Applied research is intended to lead to the solution of scientific problems. Action research could be seen as the view that research should lead to change, and therefore that change should be incorporate into the research process itself. As Herbert (1993:1) observed, there are many types of research, including field research, which contribute to knowledge and it is important to define the purpose and reasons for conducting the research at the beginning of a project.

Smith, Thorpe, and Lowe (1995) defined three common reasons for carrying out research:

"1 - To explore and describe a process or resolve some problems.

2 - To review existing theory and factual knowledge in a particular field.

3 - To construct something that is useful. For example an instrument to predict the after-effects on anaesthesia on cognitive functioning or to measure stress or perhaps create a questionnaire that reliability indicates patient/client satisfaction with the service they receive."

The research design is the response to these issues as it defines how a piece of research is planned and carried out.

According to Hakim (1987) design addresses primarily the aims, purposes, intentions and plans within the context of the practical constraints of location, time, money and availability of staff. Yin (1994:18) points out that a research design is the logic that links the data to be collected (and the conclusions to be drawn) to the initial questions of a study. Yin (1994:18) also states that every empirical study has an implicit, if not explicit, research design. Yin's observations supports Barnes (1992) position that each individual researcher approaches a research question in a different way. Barnes argues that each researcher focuses on different aspects of the research subject and use different methods from their research method "tool box" in order to answer their questions.

Smith, Thorpe, and Lowe (1995: 33) defined research design as organising research activity, including the collection of data, in ways that are most likely to achieve the research aims. There are many potential choices involved in developing a research design and the researcher's philosophical positivism or interpretations contribute to the choices made determining the elements of analysis to be engaged. There are, argue Smith, Thorpe and Lowe (1995), five key choices and the dichotomy between positivism and the qualitative or interpretative approach is always present. The position is summarised in Figure 6.1.

Figure 6.1 - The five key choices of research design

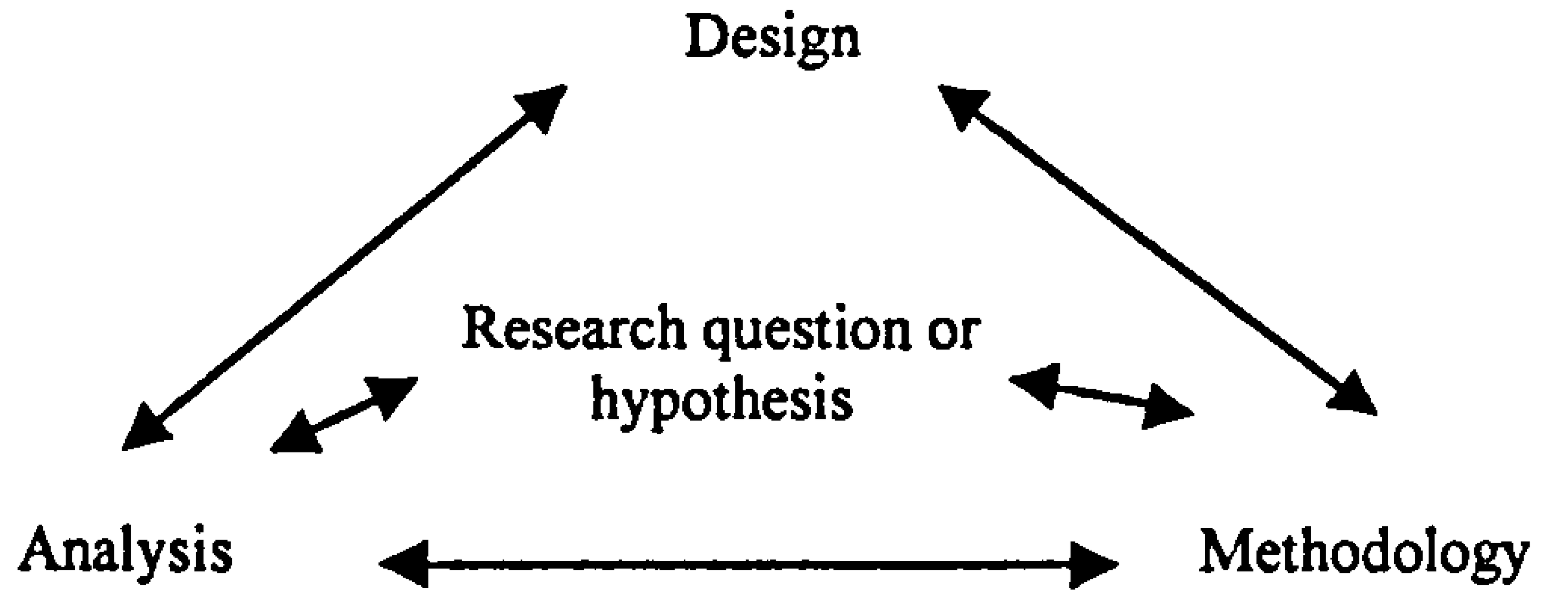
Researcher is independent	vs	Researcher is involved
Large samples	vs	Smal numbers
Testing theories	vs	Generating theories
Experimental design	Vs	Fieldwork methods
Verification	Vs	Falsification

Source: Smith, Thorpe, and Lowe 1995:33.

Young (1996) describes research design as the logical and systematic planning and directing of a piece of research. In his opinion "...the design results from translating a general scientific model into varied research procedures. The design has to be geared to the available time, energy and money, to the availability of data and to the extent to which it is desirable or possible to impose upon persons and social organisations that supply data. The most meaningful and revealing studies are those that are conceived from a definitive point of view. Although the views are modified as and when necessary in the study process, as well as those that are dominated by a definitive set of scientific interest which can be enlarge or curtailed, as the process requires".

The feasibility of the research study and the relationship between research questions, research design, methodology and analysis must be controlled. This is fundamental to the validity of the results or findings. This relationship, the practical feasibility and opportunity is represented in Figure 6.2 (Edwards and Talbot 1996:7).

Figure 6.2 – Relating question to design and methodology

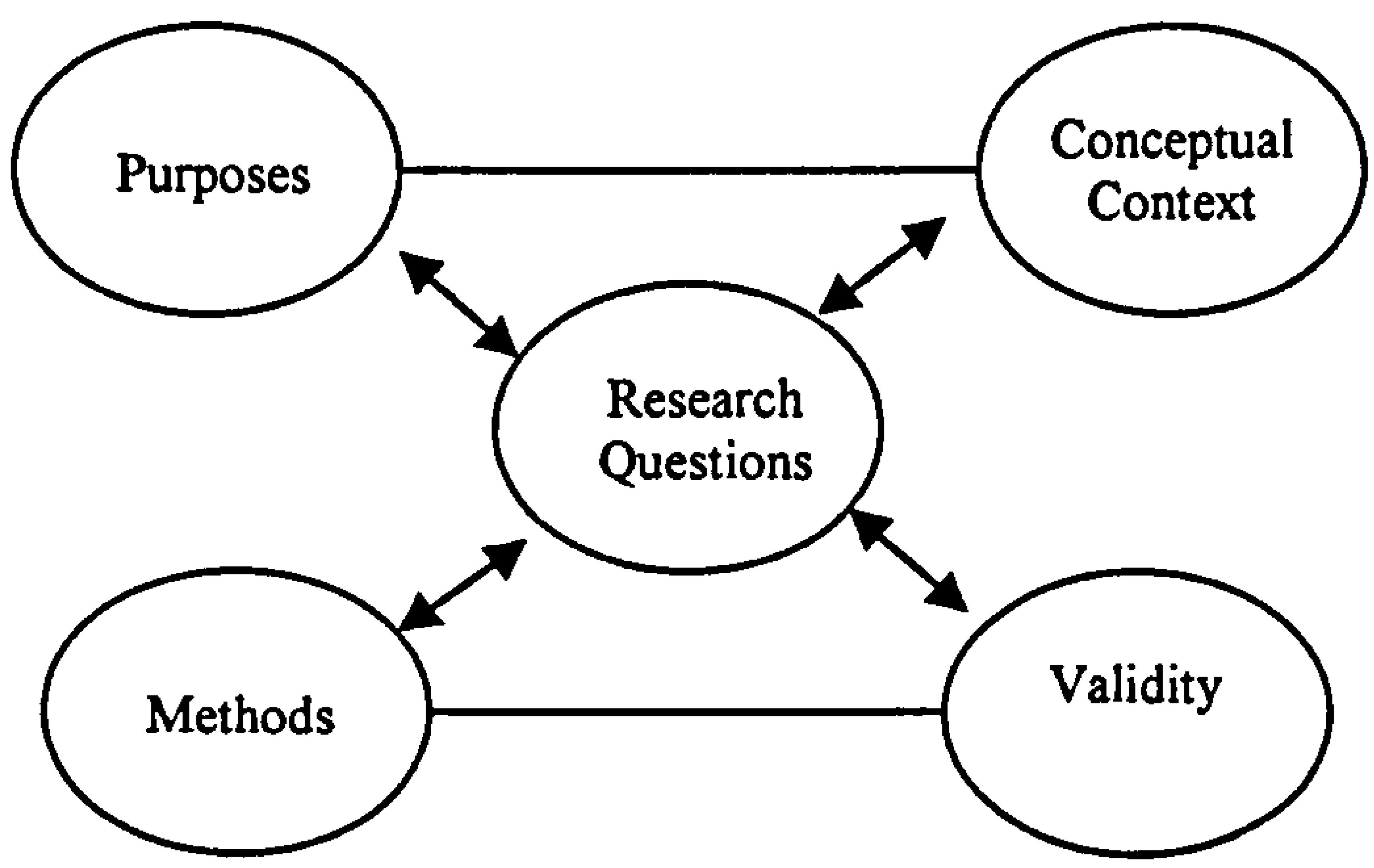


Source: Edwards and Talbot 1996:7.

The dynamics of the systems being studied are characterised by strong interactions between the parts, or the sub-systems, usually in a non-linear relationship. This feedback and iterative process is not well modelled by the classical methods and methodologies (Brandon, Lombardi and Bertivegna 1997). The reductionist science approach, the scientific method, and other classical research methods do not satisfactorily illuminate or explain dynamic systems. Dooyeweerd of natural phenomena and human life. This implies that there exists a truth that is absolute and autonomous from man and nature". Brandon, Lombardi and Bertivegna (1997) argued that this non-reductionist idea of a "cosmic law framework" freed researchers from the horns of one of the oldest dilemmas that of the objectivism versus subjectivism debate. In their opinion it opened up a new and free space to see the world. The orderliness of the universe is illustrated by matching the concepts to the natural environment and correlating them into a theoretical body of knowledge creating a new evaluation process. This modal-thinking perspective reinforces the necessity to encompass ethical issues. They are qualitative issues.

Maxwell (1996) is concerned with qualitative research design. He reinforces the importance of the design role and adopts and interactive model. He argues that the design process in qualitative research is interactive. It involves iterating between the different components of the design, assessing the implications of purposes, theory, research questions, methods and compromises threatening the validity of the work. He argues that this process is innovative in that the relationship between the components is complex. Each component, which together forms an integrated and interacting whole, is closely tied to several others rather than being linked in a linear or cycled sequence. The key relationships are displayed in Figure 6.3.

Figure 6.3 – An interactive Model of research design



Source: Maxwell 1996: Fig. 1.1:5.

A research design represents a logic set of statements. It is argued that applying certain logical tests can assess the quality of any given design. Having decided both upon the focus of the research and upon the title of the study. Adams and Shvaneveldt (1991:103) describe the research design as a "plan, blueprint or guide for data collection and interpretation sets rules that enable the investigator to conceptualise and observe the problem under study". It must be emphasised that a well designed study sets the researcher free to explore and find the connection that make research so interesting (Edwards and Talbot 1996:28). There are different research designs, for example survey, experiments, case studies, action research. Conceptually there are some overlaps between designs, which is understandable in a qualitative and quantitative approach. This is the field of the quasi-experimental methodologies.

For example experiments might not only include the positivist approach of the scientific method, the laboratory experiments but also other approaches. Smith, Thorpe, and Lowe (1995) sees the discovery of penicillin by Flemming as produced by more than the logical and rational application of scientific method. The advance resulted from independent and creative thinking that went outside the boundaries of existing ideas. The result was a "scientific revolution" which not only provided new theories, but also radically altered the way people saw the world. This was achieved by using a soft methodology approach, systems thinking, coupled with positive scientific methodology. Much of Einstein's work was based on similar approaches and thorough experiments, but he has received little attention in discussions of research designs, particularly qualitative research design (Maxwell 1996:45). This research project rests at this interface between the qualitative and quantitative approaches. The concepts, which have produced tools to judge the quality of any given design, include "trustworthiness, credibility, confirmability and data dependency" according to the US General Accounting Office (1990). McNeill (1994), argued that the research design must be judged from three fundamental positions. They are:

"- Reliability. Reliability in a method of collecting evidence, and means that anybody else using this method, or the same person using it at another time, would come up with same results. The research could be repeated with the same results.
Validity. Validity refers to the problem whether the data collected is a true picture of

what is being studied.

- Representativeness. Representativeness refers to the question of whether the group of people or the situation that is studied is typical of others.

McNeil (1994) added the generalibility, objectivity and credibility concepts as fundamental issues of the representativeness concept to these criteria, as did Robson (1995).

In empirical research, using case study design, four test have commonly been used to establish the quality of the research design (Yin 1994:33). They are:

1 - Construct Validity: establishing correct operational measures for the concepts being studied.

2 - Internal Validity (for explanatory or causal studies only, and not for descriptive or exploratory studies): establishing a causal relationship, whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships.

3 - External Validity: establishing the domain to which a study's findings can be generalised.

4 - Reliability: demonstrating that the operations of a study, such as the data collection procedures can be repeated, with the same results.

Table 6.1 listed these four widely used tests and the recommended case study tactics as well as a cross-reference to the phase of research when the tactic is to be used.

Table 6.1 - Case study tactic for Four design tests

Tests	Case study tactic	Phase of research in wich tactic occurs
Construct validity	-use multiple sources of evidence -establish chain of evidence - have key informants review draft case study report	Data collection Data collection Composition
Internal validity	- do pattern-matching - do explanation-building - do time-series analysis	Data analysis Data analysis Data analysis
External validity	-use replication logic in multiple-case studies	Research design
Reliability	-use case study protocol -develop case study data base	Data collection Data collection

Source: COSMOS Corporation in (Yin 1994:33).

The initial research question (How can obsolete buildings be deconstructed to contribute to sustainable construction objectives?) conditioned the scope of the literature review. The detailed research questions emerged from that review and as suggested by Yin (1994) they determined the research design.

Research Questions, Strategy and Methodologies

This Section considers the research questions and the strategy and methodologies to be used in order to get data from the real world process it and understand the results so that the findings can be applied to resolve the problems addressed.

The methodology is the study of the logical basis of the research, of the collecting data and of interpreting and analysing the findings (McNeil 1994). It will form the structure of a conceptual framework.

In this research the first question clearly defines the focus. The subsidiary questions deal with detail necessary to address the first question. Those details concern the nature of deconstruction process and the relationship with estimating and assessment of the construction and demolition waste stream. The methodologies studied and used create a conceptual framework and form the logical structure for the research, data collection, interpretation and analysis of the findings.

The first thing to address was a comprehensive search and review of texts that address the subject. The literature review focused on the construction and demolition waste stream in the context of the wider issues of sustainability and sustainable development. It established where the boundaries of knowledge were in the subject area and highlight the key areas where more knowledge and research was required.

Understanding the Focus and Phases of the Research

As a rule a piece of research falls within one of four areas (Herbert 1993). The research areas are:

- "To explore or to resolve some problem.

- To review effects of existing theory and factual knowledge in a particular field.

- To construct something that is useful, for example an instrument to monitor the after effects of a new industrial technology solution, to measure it effects in human health.

- To explain or clarify and achieve a better understanding by unpacking a phenomena."

A schematic overview of the research process is needed to progress. Herbert (1993) suggests a number of phases as follows:

... " 1 - Identification and clarification of the research question.

What is it we wish to find out? What is the context of the investigation? How and why do we wish to investigate this subject? What importance does it have either theoretically or practically? What have other researchers said or done about this issue?

2 -Developing a tentative answer or redefining a hypotheses.

A research problem is something that must be meaningfully, methodological or technically relevant.

3 - Finding an appropriate research strategy to test the tentative answer.

This is the selection of a broad research design. The main criteria can be summed up in two questions: Does the design contribute to generate answers to the research question? Does it adequately test the hypotheses or the prior questions?

4 - Planning the fine details of the study and the means of collecting data.

In terms of the details planning of the study, there are three essential questions to address:

a) What is the nature of the research question?

b) What am I studying?

c) How do I measure the performance of the variables in which I am interested? Or how do I understand the phenomena that I am studying?

5 - Collecting the data.

6 - Arrangement, treatment, analysis and interpretation of data. How, why, where and when can the data be collected from the fieldwork? Which criteria and rules need to be followed in the data collection process?

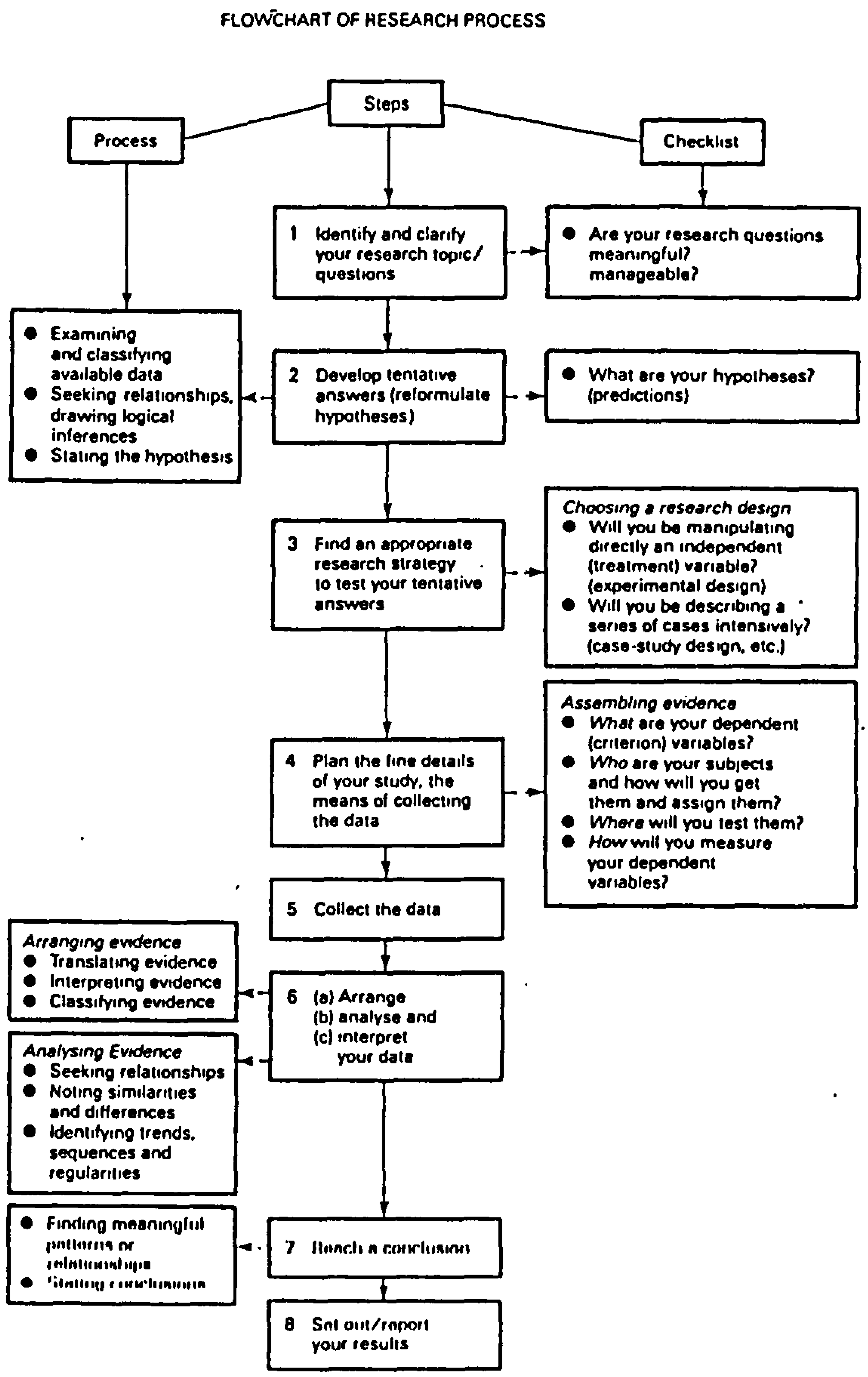
7 - Reach the conclusion and set out the report results." .

This is the final phase and the results obtained by the application of the methodological procedures, must be significant and complete in the research context. The final written report must cover the research aim and objective. A flowchart of this research is shown in Figure 6.4.

This research falls within the last of Herbert's (1993) categories. It aims to explain or clarify and achieve a better understanding by unpacking a phenomenon. It is focused on a dynamic global system, which can be labelled the Building and Constructing Environmental Impact System. The detailed focus is on the Construction and Demolition Waste Sub-system.

A fundamental question is how the nature of the deconstruction process influences reuse and recycling and how that can be increased in order to move towards sustainable construction. It includes understanding the role of the actors and the external conditions of the construction industry. Morgan and Argus (1995:Part 3-Recommendations: 31) highlighted the necessity of co-operation by stating: " Waste collection authorities and the construction and demolition industries should co-operate in the setting up of separate storage and collection systems for construction and demolition wastes. Member States should encourage this and inform The European Commission of: the actions they have taken; and the system set up." This study has been carried out on the construction and demolition waste stream, and the debris trail focuses on rehabilitation waste. Besides the necessity of collecting of data, it will be necessary to develop and evaluate a methodology that gives insights into the relationship of the quality and quantity of the demolition waste stream and the basic characteristics of the deconstruction process. The approach to collecting the data was via multiple holistic case studies, because they were a significant source of real data for this research.

Figure 6.4 - Flowchart of the Research Process



Source: Herbert 1993:5.

The characteristics of the field work and the necessity to collect data from different buildings in different locations with different characteristics led to the decision to adopt multiple case studies as a research methodology. The problem was to develop the field data collection without reliable actors being involved and without a selective demolition project. A selective demolition project would have assisted in accurately establishing the quantities and qualities of waste stream. To collect data a multiple holistic case studies design (Yin 1994:39) supported by five case studies in the Lisbon was developed. The findings later contributed to the design of a construction and demolition waste stream model. The model was constructed with the findings of the Lisbon case studies and with information and data from studies developed in France (ADEME 1998). It contributed to the definition of estimating and assessment of the waste stream and the correlation of these items with the nature of the deconstruction process. It illuminated the relationship between the characteristics of the debris trail in the deconstruction waste stream and the nature of the deconstruction process. The objective was to define and construct a model that could be a significant tool in the development and management of the future Portuguese Strategy Plan for the construction and demolition priority waste stream.

Yin (1994:44) points out that each intervention in "real world" might be the subject of an individual case study and a number of case studies combined into a multiple case study design. No broad distinction is made between the so-called classic, that is single, case study and multiple case-studies. The choice is considered one of research design, with both being included under the case study strategy (Yin 1994:45). Soft systems methodologies, systems thinking and systems practice (Checkland 1991) is the most appropriate methodology to achieve understanding of the qualitative and quantitative characteristics of the research. The interconnection of soft system methodology with the system dynamics approach (Wolstenholme 1990) opens up the possibility of dealing with the dynamics of the process. The reality is that all human beings live in a complex, dynamic reality of natural and social systems. Wolstenholme defines the approach as a "...rigorous method for qualitative description, exploration and analysis of complex systems in terms of their process, information, organisation boundaries and strategies; which facilitate quantitative simulation modelling and analysis for the design of system structure and control". It has been argued that the best way to define a problem is by drawing on its behaviour through time. This was when the use of the systems dynamics concepts was proposed (Cover 1996).

Forrester (1980:9) points out that the case study method is the best approach to understanding the qualitative issues. This is, he argues, "By virtue of its tremendously large database, the case study approach has a great advantage over the more mathematical, statistical, and analytical approaches, which often dominate operation research economic and management sciences." He goes on to say "But the case study method is still hampered by having no adequate way of interpreting its data into dynamic implications" (Forrester 1980:10). System dynamics is an extension of the case study method and overcomes the deficiencies observed by Forrester. The soft systems methodology uses a particular set of ideas, aimed at giving insight into the world's complexity. It is a process of tackling the "real world" problems, trying to manage situations with an organised set of principles or methodologies, which guide the actions. "System Thinking" develops and compares models in the thinking world and returns to the "real world" to compare solutions, to select feasible and desirable changes and finally to improve action towards the problem solution (Checkland and Scholes 1990:27). The combination of these two methodologies, case study and soft system methodologies illuminate the links between the characteristics of the waste stream and the nature of the deconstruction process. The case study from a quantitative position gives "inquiry from outside" whereas the qualitative methodology gives "inquiry from inside". There is a need to create a balance between hard-generalised data, and the rich, observational data, which results in a combination of both, in a single strategy.

The need to identify and unpack the construction and demolition waste stream more clearly is a real world problem. Knowledge is a prelude to understanding rather than for action. It is a prerequisite to pursue the new sustainable construction process. It is necessary to develop the work and obtain more accurate data from holistic case studies. The goal will be to minimise the consumption of natural resources, energy and costs while changing the general attitude towards the environment (Morgan and Argus 1995:Part 3 - Recommendations). The first requirement to select the case studies in Lisbon area was to define the principal structural features of the buildings, which were the unit of analysis of this research. An initial survey of Lisbon buildings divided them into four structural types related to the different construction times and the different characteristics of construction and materials used (Cabrita, Aguiar, and Appleton 1993).

A pilot study was undertaken to test the strategy (Procesl 1997:86-87). The pilot study had the specific objective of exposing the boundary of knowledge and the state of the art in dealing with the construction and demolition waste stream in Portugal. The technology and the decision process that lead to the use of that technology was established through observation and interviews. Soft systems modelling was used to model the relationships. The whole process was compared with the outputs of previous research. The findings were then integrated to produce a model that clarified the problem definition and simulation. Most systems are not in equilibrium and their conditions are continuously changing. In order to understand, adapt to and control this reality, methods must be developed to capture it in formal models. There is a need to use systems dynamics modelling to illuminate and give insight into the variety and complexity of the systems being observed. The understanding of the importance and interrelationship between the quantitative and qualitative approaches is fundamental to this research. The next Section discusses these two traditions in research. The quantitative methodologies emerging from positivism and the qualitative methodologies from phenomenology.

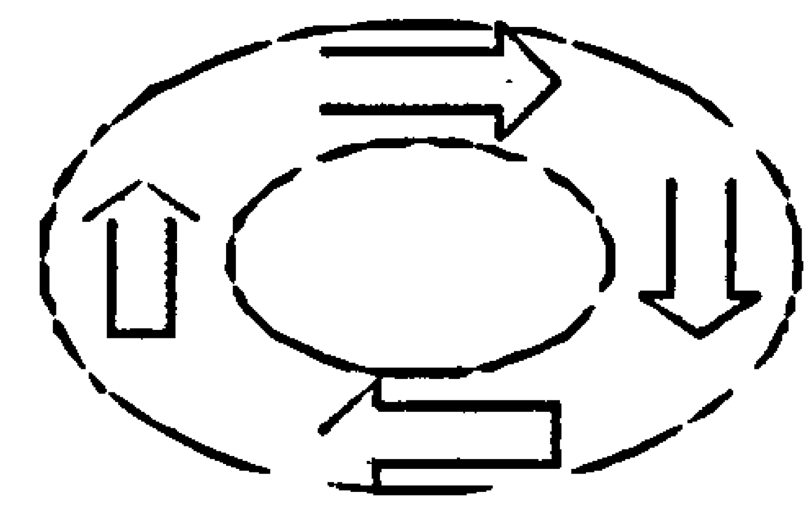
SECTION 2: THE QUALITATIVE AND QUANTITATIVE METHODOLOGIES APPROACH

There has been a long–standing debate in the social sciences about the most appropriate philosophical position from which methods should be derived (Smith, Thorpe, and Lowe 1995:22). There are two main research traditions, positivism and phenomenology. Each of these traditions has to some extent been stereotyped, often by those adhering to the opposing tradition. The key idea of positivism is that the social world exists externally, and that its properties should be measured through sensation, reflection and intuition. This position was stated by the French philosopher Auguste Compte in 1853 (Smith, Thorpe, and Lowe 1995:22).

August Compte (1853) was an early and influential proponent of the positivist position. He said "All good intellects have repeated, since Bacon's time, that there can be no real knowledge but that which is based on observed facts". This statement contains two assumptions: firstly, that reality is external and objective, secondly, that knowledge is only of significance if it is based on observations of this external reality (Feibleman 1986). A new paradigm has arisen largely as a reaction to the application of positivism to the social sciences. It emerged during the first half of the 20th century and stems from the view that the world and "reality" are not objective and exterior, but are social constructs given meaning by people (Husserl 1946). This "phenomenology" is not logically derived from positivism in any way. According to Smith, Thorpe, and Lowe (1995:24) it is based on the idea that reality is socially constructed rather than objectively determined.

The two traditions represent different approaches to research: the inductive method and the deductive method. Positivism is the inductive methodology. It is quantitative following the scientific model working from data to theory. There has been a trend away from this approach to the deductive methodology, phenomenology. Deductive research, working from theory to data, is more interpretative or qualitative. The positivist research tradition has a commitment to objectivism, value-free science and reliability. Phenomenological researchers adhere to an interpretative model, which holds that there is no objective reality independent of social meaning given to it by those in the setting (Bailey 1996). Figure 6.5, adapted from Bailey (1996:26) represents the research process as a wheel. Using the scientific method, the inductive process, the researcher enters the research circle at the point of data collection and travels up the left side of the wheel. Data is collected and then extrapolated for insights. During deductive research, the researcher moves from theory to data collection. The purpose of this type of research is usually explanatory or theory testing.

Figure 6.5 – The research wheel of science



Source: Bailey 1996:26.

There are strengths and weaknesses in both traditions and a paradigm has been growing which recognises those characteristics. It is a research denominated quasi-experimental methodology, which takes into account the features of each one and the reality of the research. It is this approach which has been chosen for this research. The research needs to deal with quantitative issues without losing the qualitative characteristics of the study into the waste stream using a global systems dynamic overview (Wolstenholme 1990). The interrelationship and interaction between the real world of the experiences and that of the data coupled with the necessity to deal with conceptual models justifies the use of soft systems methodologies (Checkland 1991).This research was developed using qualitative methodologies to collect hard data from case studies. Soft system methodology was used to structure the data and illuminate the inputs and outputs. The approach gave insights into the interrelationship between the real world of data collection and system thinking, where arrangement, treatment and interpretation of data occurred.

The system dynamics contribution was fundamental. The construction and demolition waste stream is a naturally dynamic system and requires a dynamic simulation model. That is provided by system dynamics modelling tools.

The Case Study Methodology

A case study has been defined as "an empirical enquiry that investigates a contemporary phenomena within is real-life context; when the boundaries between the phenomena and context are not clearly evident and which multiple sources of evidence are used" (Yin 1994).

Case study is one of several methodologies for undertaking and understanding research. Initially it was applied mainly to the social and humanistic sciences but has increasingly been applied to the engineering field. Each case study strategy has peculiar advantages and disadvantages Yin (1994), depending upon three main conditions:

a) - " The type of the research question posed

b) - The extent of control an investigator has over actual behavioural events"

c) The degree of focus on contemporary as opposed to historical phenomena

Case studies may be used for a specific function of the research. Appropriately they can be used at the exploratory phase of an investigation. They can be used descriptively recording surveys and histories and for thirdly for explanatory or causal inquiries. The way in which the case study is used derives from the distinctive characteristics of each situation Yin (1994:1). In this research the case studies are used to describe the dynamics observed in the "real world" of the construction and demolition waste trails.

Case study research is more appropriate to questions of how and why in the context of the type of research question addressed. A study from Cosmos Corporation presented by Yin (1994: 6) in Table 6.2 gives an overview of relevant situations for different strategies.

Table 6.2 – Relevant situations for different research strategies

Strategy	Form of research question	Requires control over behavioral events ?	Focused on contemporary events ?
Experiment	How, why	Yes	Yes
Survey	Who, what, where, how many, how much	No	Yes
Archival analysis	Who, what, where, how many, how much	No	Yes/no
History	How, why	No	No
Case study	How, why	No	yes

Source: Cosmos Corporation, in Yin 1994:6, Fig.1.1.

When designing case studies the initial questions of the study determine the data that needs to be collected and the processes required to draw the appropriate conclusions. Therefore every case study has an implicit or explicit research design. Four major types of designs are relevant according (Yin 1994:38), and they could be grouped into a 2x2 matrix. This shows single and multiple case studies, studied in combination with the unit or units of analysis, as well as distinguished between holistic or embedded designs. Table 6.3 presents this 2x2 matrix, with the basis types or designs for case studies.

Table 6.3 – Basic types of designs for case studies

	Single-case designs	Multiple-case designs
(single unit of analysis)	TYPE 1	TIPE 2
Embedded (multiple units)	TYPE 2	TYPE 4

Source: Cosmos Corporation, in Yin 1994:39, Fig.2.4.

Case study methodology is often criticised. The criticism of case studies as a scientific method can be summarised according to Gummerson (1991: 77) under the following three headings:

- " Case studies lack statistical validity.

- Case studies can be used to generate hypotheses but not to test them.

- Generalisations cannot be made on the basis of case studies.

Other authors such as Bell (1995: 8) point out that the great strength of the case study methodology is that it allows the researcher to concentrate on specific instances or situations and to identify the interactive and causal processes of work. Bassy (1981) considers that a successful case study will provide the reader with a three dimensional picture and will illustrate relationships, micro political issues and patterns of influence in a particular context. Bromley (1986) sees individual case study or situation analysis as "the bedrock of scientific investigation". This is a large debate, with different but understandable opinions. However the importance of the case study is that it provides a holistic view of a process whereas a reductionist method dissects the complex whole and studies the simpler parts or components out of context. According to the holistic and systemic view, the whole is not identical to the sum of the parts.

The management of construction and demolition waste trail is directly linked to the broader area of construction management where case study methodology has been used. McDermott (1995) developed research with the purpose of introducing the case study approach as a research tool for researchers in property or the construction industry (McDermott 1995). As McDermott (1995) points out case studies involve a consideration of the philosophical context and qualitative research. Works by Bryman (1989), Bresman (1966, 1990, 1991) and Yin (1994) develop the arguments for the use of this research methodology.

Construction management research has been subject to several reviews in terms of content, conclusions and methodologies. In a field appraisal in 1980, Harvey

(1994) concluded, "urgent steps should be taken to improve the methodology of research in construction management". Academia is concerned with intellectual display and understanding selected problems of the construction industry. Practice is concerned with "getting the job done", finding pragmatic solutions to problems as they arise. Although people move between academia and practice they tend to adopt the philosophy and modes of working appropriate to the world in which they are employed (Boyd and Wild 1995). Lanslay (1990) identified the construction management researcher, which included demolition management, as "a lone figure often working in an organisation which has little experience of management research". He identified difficulties with financial and technical support.

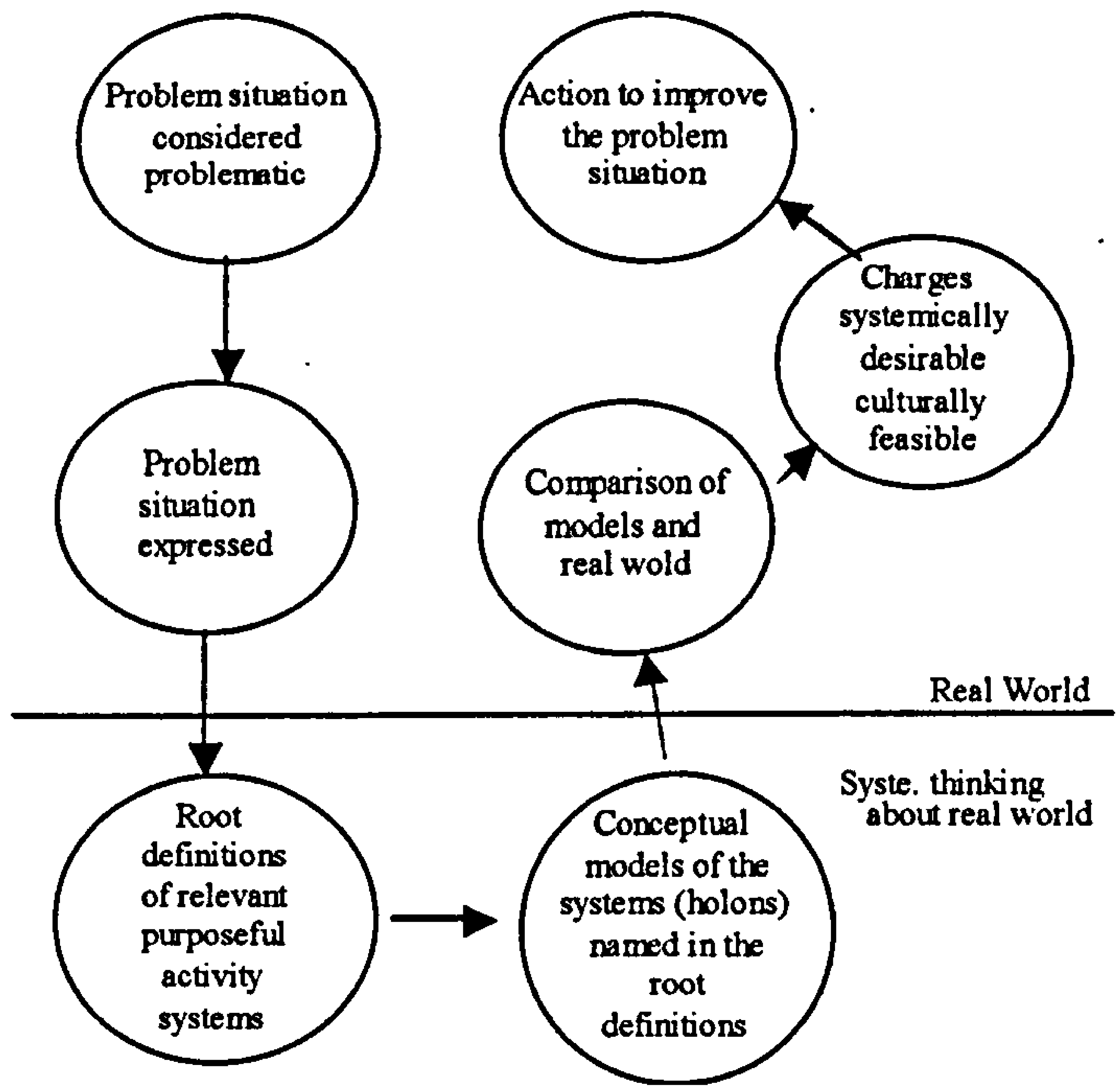
This research is grounded in both academia and practice. It extends the boundary of knowledge of the issues which it addresses whilst providing a platform for advances in practice.

System Thinking and Soft System Methodology

Soft systems methodologies use a particular set of ideas to illuminate world complexity. It is a process of addressing "real world" problems to enable the management of a situation using an organised set of principles or methodologies to guide the actions. The basic shape of the methodology is to formulate a model which it is hoped will be a near match to the real world situation. Then, by a process of comparison with perceptions of the real world, refine the match (Checkland and Scholes 1990:6).

The systems enquiry, systems thinking and practice approach is presented as a model by Checkland and Scholes (1990:27). It is a conventional seven-stage process, in a chronological sequence. The process is shown in diagrammatic form in Figure 6.6.

Figure 6.6 – The methodology in summary



Source: Checkland and Scholes 1990:27.

Checkland (1991:162) has shown that is possible to start a project at any stage of the process. It is essential that the process be seen as iterative with interactivity between the earlier and latter stages. This is because the methodology is itself a system where a change in any one stage affects all the others (Checkland 1991:163). Most users of the methodology have used it as a framework into which to place purposeful activity during a system study. The methodology contains two kinds of activities.

Stages 1,2,5,6, and 7 are "real world" activities, necessarily involving people in the problem situation, and depend upon the individual circumstances of the study. Stages 1 and 2 are the "expression phase" during which an attempt is made to build up the richest possible picture of the situation. Stages 3,4, are "systems thinking" activities which may or may not involve those in the problem situation.

The first and second stages are related to the collection of as many perceptions as possible building the richest possible picture of the problem. Stage 1 deals with unstructured ideas. Stage 2 defines the problem situation more clearly. These two stages belongs to the "real world". In this research the design begins in stage 2, as the research ideas are well structured. The third stage is related to the choice of the root definition of a relevant system.

The "root definition" should be a concise description of a human activity system, which captures a particular perspective. It expresses the core purpose of a purposeful activity system. This is always expressed as a transformation process. The transformation process is one in which the inputs of an entity are changed or transformed into some new form, the output of the same entity. In this research a "root definition" was established. That led to an activity subject to the transformation process. That activity and transformation process was the nature and form of the deconstruction process. An objective was the conceptualisation of an estimating and assessment model of the debris from the process.

The definition of an appropriate "root definition", which is the core of the purposeful activity, is fundamental in the research development. This study highlights the construction and demolition sub-system within the global building and construction environmental impact system. A well formulated "root definition" should be prepared by consciously considering the elements that make the mnemonic CATWOE. Checkland and Scholes (1990:35) defined the elements of CATWOE as follows:

- "C" is for the "customers": the victims or beneficiaries of the transformation process (T), the users, the global community.

- "A" is for the "actors": those who would do the transformation process, the Public Authorities, the developers, the contractors, the workers.

- "T" is for the "Transformation Process": the conversion of input to output. In terms of the dynamic model it will be the unpacking of the construction and demolition sub-system, the study of that system and repacking it again.

- "W" is for the "Weltauschauung": the worldview that makes this (T) meaningful in context. In this situation the world needs to be resource efficient and this process will contribute to that end in an area which is manifestly not resource efficient.

- "O" is for the "Owners": those who could stop (T), the Public Authorities, the developers, the contractors, the workers and the community

- "E" is for the "Environmental Constraints": elements outside the system that can prevent (T) occurring. This could be the lack of training, or qualified labour, inappropriate equipment, difficulties resulting from boundaries restrictions, energy requirements or restrictions, lack of security, environmental or natural restrictions, or legal restrictions on the production of noise, dust or other pollutants.

The structure of CATWOE implies that the simplest version of the root definition would be " a system to do X" where X is a particular transformation process (T).

The fourth stage of the process is the construction of the model of the activity system needed to achieve the transformation described in the definition. The conceptual model must take into account all of the activities that the system must do in order to match the system named in the definition. The fifth stage compares the conceptual model with the reality. The sixth stage focuses on systemically desirable and cultural feasible changes. These could be changes in structure, in procedures and in attitudes. The purpose of the stage is to generate a debate with people concerned with the problem. The outcome of the debate is to define possible changes that simultaneously need to meet two criteria. Those criteria are that the changes are arguably desirable and feasible given prevailing attitudes and power structures, and having regard to the history of the situation under examination.

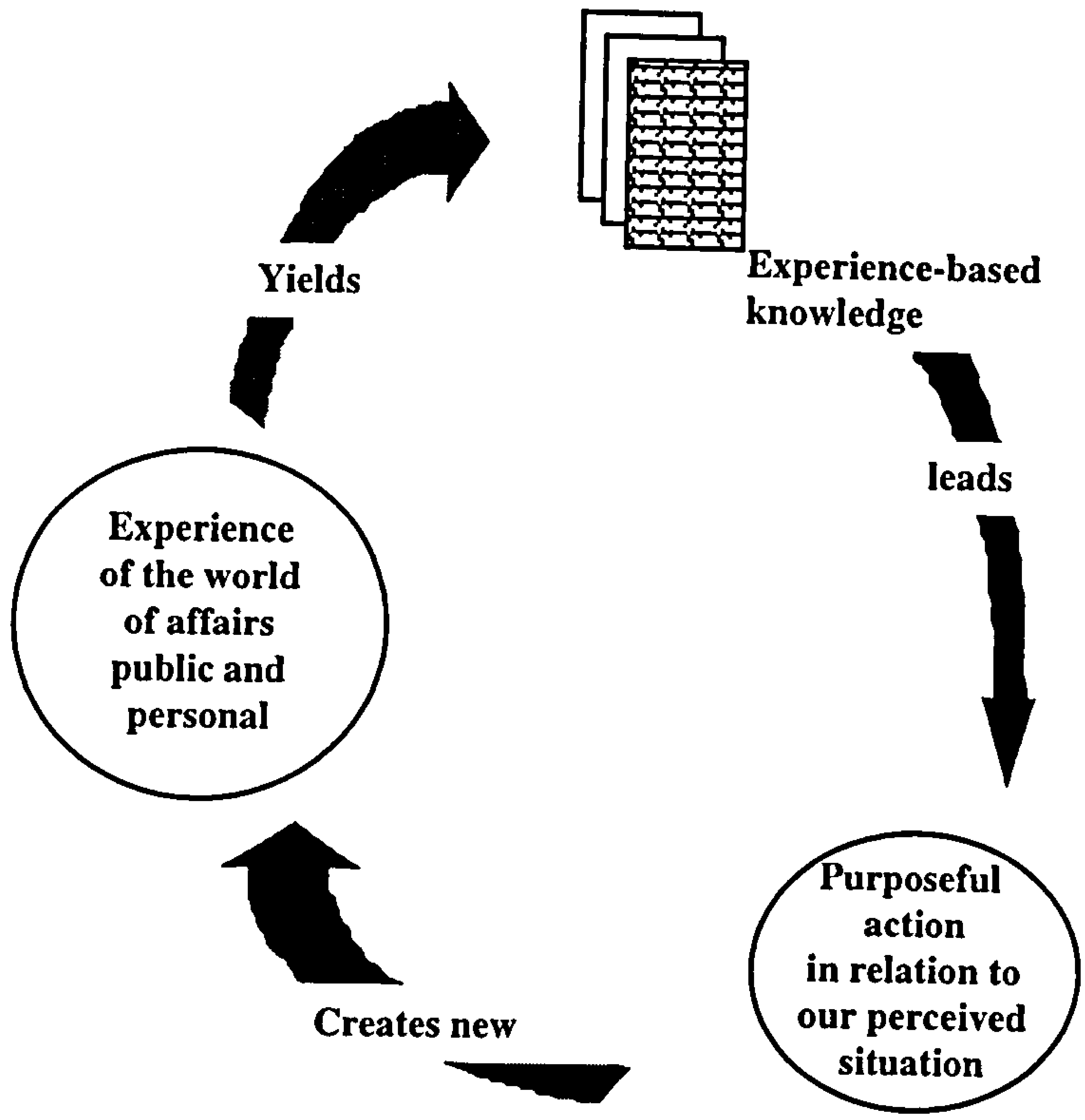
The last stage involves taking action to mitigate the problem. This defines a "new problem" and it too may now be tackled using the methodology. Within this research, the customers are the community in its broad sense. The community is the beneficiary of the environmental and sustainable practices. The actors (A) are the people participating from the design phase, through construction and maintenance to the deconstruction phase. The transformation process (T) in this research, is the deconstruction process, and the study of its nature and the definition of materials to be reused and recycled.

The "weltanschauung" (W) is that the world needs to be resource efficient and this process will contribute to that end in an area which is manifestly not resource efficient. The owner (O) is the building controller. That is the person who has power to decide that the building should be deconstructed. It also includes those who are responsible for the deconstruction. Finally, the environmental constraint (E) are the elements outside the system.

The central concept of a system embodies the idea of a set of elements connected together which form a whole, where the whole is more than the sum of its parts. The system shows properties that are properties of the whole system, rather than properties of its component parts. The phrase "system thinking" implies thinking about the whole model, the synergy of parts of the real world situation.

One of the most obvious characteristics of humans is their readiness to attribute meaning to what they observe and experience. These attributions are based on previous experiences and knowledge. Thus humans attribute meaning to their experience of the world. They then decide to take purposeful action, or not to act, in response to those experiences. Figure 6.7 presents the idea that the purposeful activity derived from knowledge will result in a new experience.

Figure 6.7 – The experience – action cycle



Source: Checkland 1991:3.

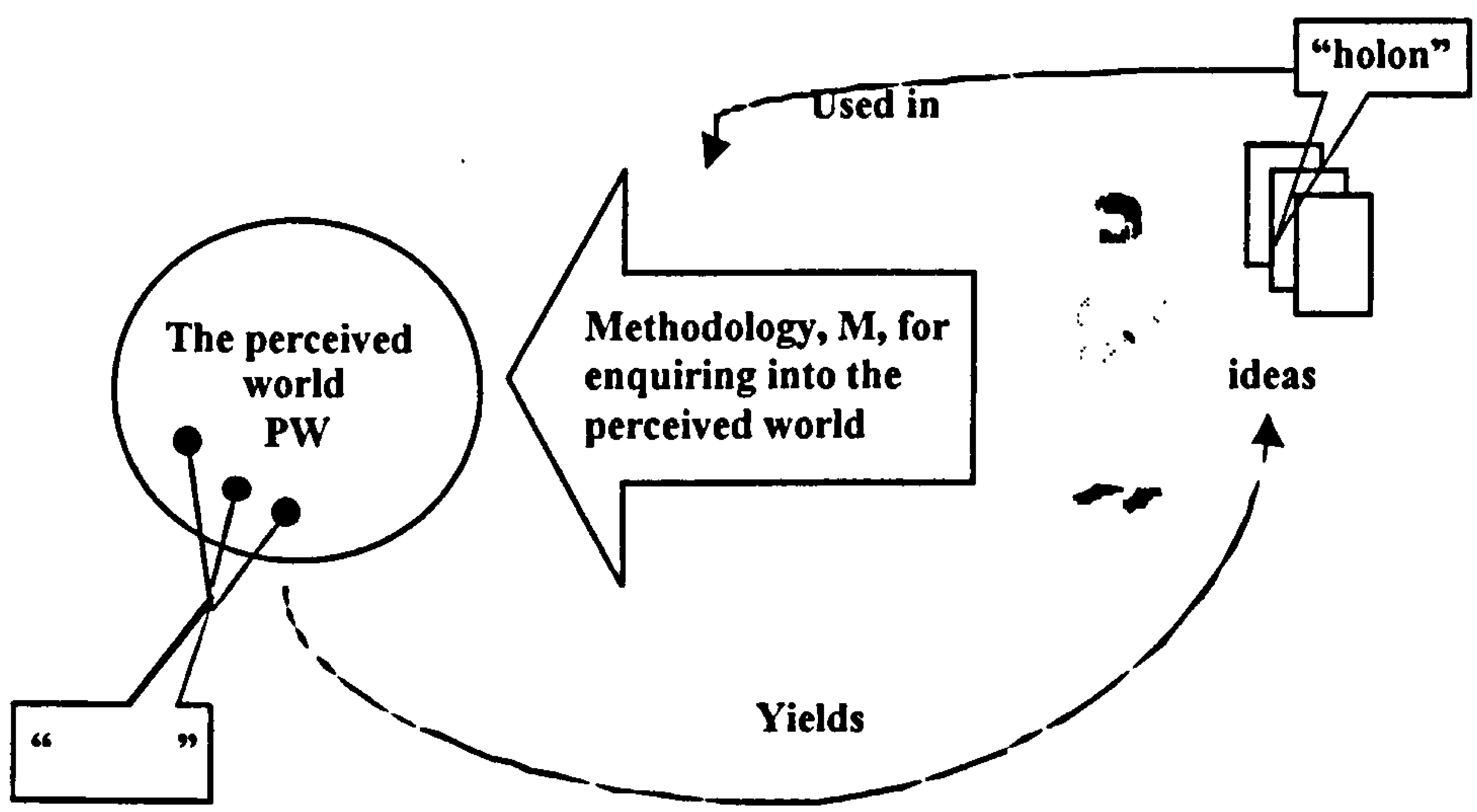
The focus of soft system methodology is to guide, based on system thinking, the management of, in a broad sense, the real world's problematic situations. It is aimed at taking purposeful action or activity to constructively change the real situation. According to Checkland (1991) it is possible to condense this view in the following way:

... " Human beings cannot help but attribute meaning to their perception of the world. Those meanings constitute interpretations of the world, which can be thought of as deriving from experience-based knowledge of the world. The interpretation can inform intentions which can translate into purposeful action to improve situations perceived as lying somewhere on a scale from "less than perfect" to "disastrous". Purposeful action when taken changes the world as experienced as indeed does the mental act of interpreting it so that we can constitute cycles. The cycles can be expressed and operate by making use of systems thinking as an epistemology."

Soft System Methodology does that in a coherent process, which is an enquiring or learning system and within the process uses models of purposeful activity systems. The methodology seeks to provide help in articulating and operating the learning cycle from meanings to intentions to purposeful action without imposing the rigidity of a technique.

The nature of systems thinking must be systemic. Within the systems movement there are two complementary schools, usually labelled "hard" and "soft". Hard system engineers tackle rather well defined problems, while soft systems methodologists address messy, ill-structured problem situations. Whilst this is true it is not the fundamental difference between the complementary schools. Hard system thinking assumes that the perceived world contains holons. Holon derives from the Greek word holos meaning combining, whole (Oxford Dictionary 1995). Soft system thinking takes the stance that the methodology, the process of enquiry, can itself be created as a holon. Soft System Methodology is a cyclic methodology that is a holonic process. It is a process where the procedures make use of models of holons. Figure 6.8 shows the key differences.

Figure 6.8 – The shift in systemicity between Systems Engineering and Soft Systems Methodology



Source: Checkland and Scholes 1990:23:Fig. 2.3.

The idea of a system as a whole concept and the necessity for it to include the soft and hard positions suggests that the word holon (Koestler 1967) better describes the process as an alternative to world system. In systems thinking, accounts of wholes are formulated as holons (Checkland 1991). Two pairs of ideas can express a complete definition of a system, they are emergence and hierarchy, communication and control (Atkinson and Checkland 1988). Holons represent the abstract idea of a whole having emergent properties, a layered structure and processes of communication and control which in principle enable it to survive in a changing environment (Checkland and Scholes 1990:22). These can be set against the perceived world, in order to learn about it.

As Checkland (1991) states "...engage with the world by making use of concepts whose source is our experience of the world; this process of engagement, usually unconscious as we live everyday life, can be made explicit." System thinking is based on that idea.

System Dynamics Methodology

According to Wolststenholme (1990: 1) "...the word "system" is used to denote any combination of real world elements which together have a purpose and which form a set which is of interest to the inquirer". Systems Dynamics is centred on the use of influence diagrams to construct models of systems in terms of their processes. The aim of the methodology is to observe and identify problematic behaviour of a system over time with the objective of creating a valid diagrammatic representation (or model) of the system. That model must be capable of reproducing (by computer simulation) the existing system behaviour. The changing behaviour may be, for example, from decline to growth or from oscillation to stability.

Forrester working on the basic patent for magnetic core memory undertook the pioneering work on System Dynamics, which began in 1956 at MIT School of Industrial Management. He realised that the principles of feedback control used in his electro-mechanical research might be applicable to socio-economic systems (System Dynamics Society 1997). This application of principles across a disciplinary boundary was fundamental to the development of models for the better understanding of physical and social systems.

In 1961 Forrester (1961) introduced the concept of Industrial Dynamics. It was the application of feedback principles and simulation to aid the management of a company. It illuminated systems by the rigorous study of feedback, dynamics and simulation models. The underlying characteristics of the system dynamics tools created insights into reality. These characteristics are:

- Concentration on dynamics and feedback relationship.
- Representation of decision-making behaviour based on actual information availability.
- Explicit recognition of disequilibrium and the process of adjustment.
- Incorporation of non-linear relationships when appropriate.
- Quantification of unmeasured but important concepts and relationships (Forrester 1968).

Since Forrester's initial breakthrough many new developments in the subject area have come from many parts of the world.

There are two important characteristics of System Dynamics that arise from its holistic viewpoint. The first is the ability to generate structures that can be transformed to create insights into other systems. The second is the ability to assist in identifying the behaviour of systems. The word "structure" refers to the process and information structure of the system and is the information feedback structure of the system. Hence, system dynamics models are often described as taking a feedback perspective of a situation (Wolstenholme 1990:4).

The methodology is centred on the use of diagrams as a medium to transmitting mental models and illuminating changing states and behaviour. The systems dynamics method is based on the premise that systems are composed of two basic components:

a) Process structure, represented by resource flows, made up of levels and rates, which can be described by two type of diagrams (pipe and influence diagrams). In influence diagrams the direction of the change in magnitude of the information link is specified by the polarity of the arrows.

b) Information structure, which will convert into closed loop models. The important idea in closed loop models is that information flows link knowledge about levels to rates. They specify how the rates are to change in the future which change the quantities of the resources in the levels.

There are also two generic building blocks, which can be used to represent structures as flows and information flows. In Systems Dynamics concepts the first step is to understand the concept of a system. A simple definition is that a system consists of elements and their interconnections (Cover 1996:21). Reference modes are used to see the system's behaviour over time and the nature of the connections between elements. It is the elements of a system and the connections between them (referred to as structure) that create the system behaviour over time. System dynamics is the practice of modelling problems, not systems. Problem definition and setting model boundaries are inextricably linked and determine the structure of the model to represent the problem accurately (Cover 1996:21). There are a number of other concepts, tools and rules in System Dynamics.

Open-loop thinking describes a linear pattern of events without reference back to patterns over time. It is presented in Figure 6.9. There is no feedback. The common definition of a feedback is the transmission and return of information.

Figure 6.9 – Open-loop thinking

Problem → **Plan** → **Action**

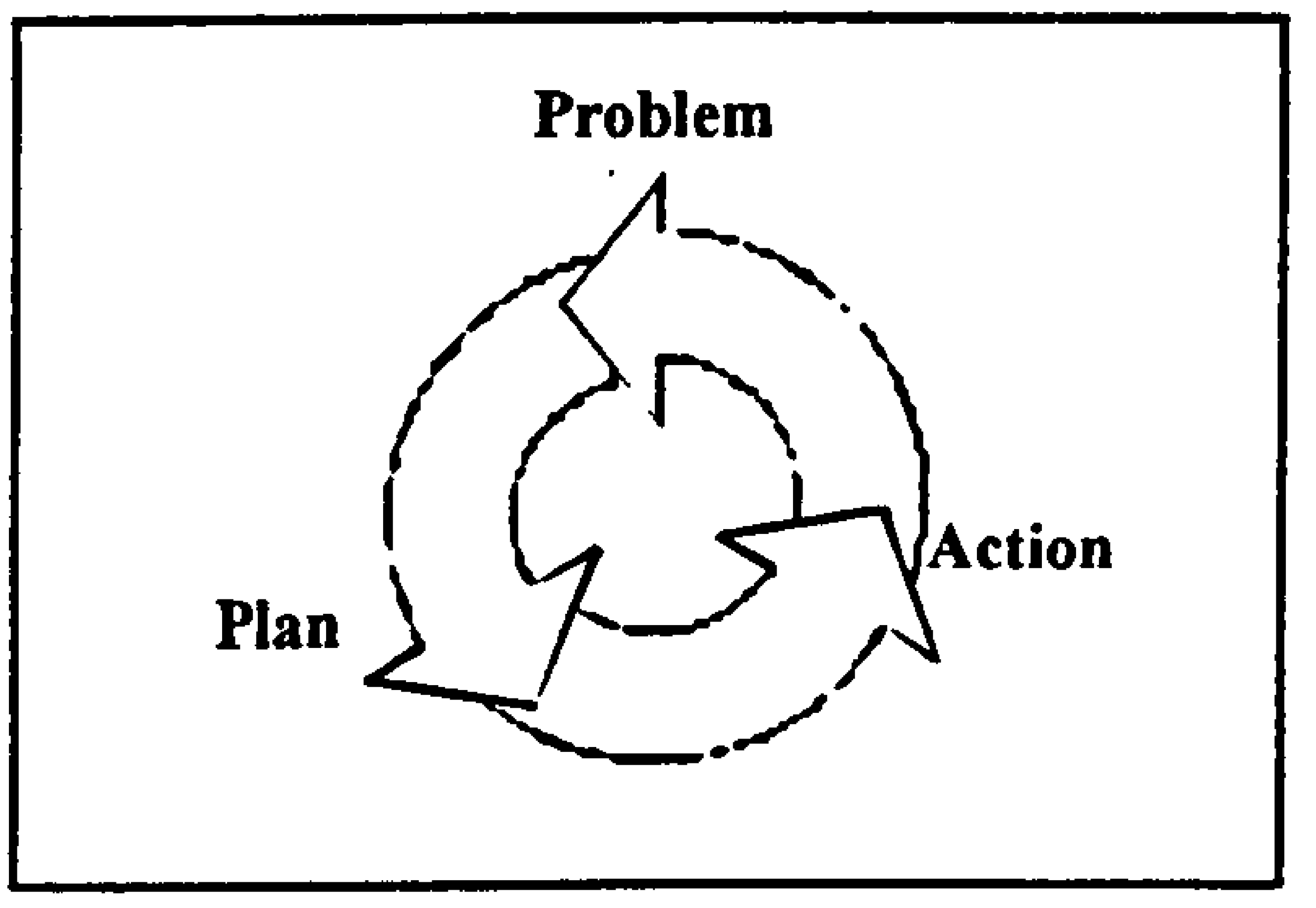
Source: Cover 1996: 22.

If a problem is identified, a plan formulated and action follows that leads to the redefining of the problem it is known as a feedback loop. This is a close path that shows the circularity of cause and effect (see Figure 6.5).

There are two types of feedback loops, positive and negative. They occur inside the structure of interacting feedback loops and within the closed boundary of a model. Positive feedback loops are sometimes called reinforcing loops. They always create a growth process. Negative loops are goal-seeking loops. They stabilise or eliminate systems. They tend to move a system toward a desired level or goal and are sometimes referred to as balancing loops.

Every element in feedback loops (Figure 6.10), and therefore every element in a system, is either a stock or a flow. Stocks are accumulations and flows representing the systems activity. Flows are dependent on the values of the stocks, never on the values of other flows. They fill up or drain stocks just as the flow of water into a bath fills it and the drain empties it. This action, of flows and accumulation of stocks, is the cause of all dynamic behaviour in the world and are fundamental engineering principles (Cover 1996:26).

Figure 6.10 - Feedback loop



Source: Cover 1996:22.

This research addresses questions which involve feedback loops. A key area of the investigation concerns the human response to the issues faced, the research question 6. At the heart of that question lies the relationship between policy and the individual decisions of the actors working to the policy. Individual decisions are taken which stem from and are intended to enact the policy. The cumulative effect of individual decisions may not reinforce the policy. Whilst it is possible that the actions might stabilise the outcomes on the intended policy, the intended outcome, the actions might equally reinforce the policy to a point which creates outcomes which were never intended. Equally possible is that the individual decisions that appear to enact the policy might cumulatively negate it. It is also possible for the policy to create situations requiring unacceptable decisions which when not enacted change the policy. These iterative processes are essentially modelled by feedback loops.

Delays are insidious characteristics of systems. They increase the difficulty of solving problems by separating the causal symptoms from the system problems. The longer the delay between the advent of a problem and the time when the problem becomes apparent, the more difficult it is to solve. It also makes it more difficult to resolve the problems once they are discovered. Systems also contain constants which are unchanging values occurring over the time period of the simulation.

The nature of the research questions of this study was such that they needed to draw on the strengths of both system thinking and system dynamics. The strengths of both the hard and soft approaches are needed to provide appropriate answers to the questions posed by the research. It is therefore necessary to explore the interrelationship between the methodologies to establish the feasibility of combining them to address the research questions raised. The next Section addresses that issue.

SECTION 3: AN OVERVIEW OF THE INTERRELATIONSHIP BETWEEN THE METHODOLOGIES

The purpose of this Section is to explain the commonality of the two processes and show how they were combined to illuminate the research questions. The research questions required data to be collected from five renovation projects of buildings in the Lisbon municipality. The data from these case studies was complemented, with information and data from French experiences (ADEME 1998). The Lisbon case studies included the study of the relationship between the real world of collecting data and the human responses of the different actors involved in and affected by the data collection. Soft systems methodology and systems thinking were used to study the influence of the actions of the actors on the results of the fieldwork. It is one of the best methodologies to illuminate and give insight into the "real world" of data collecting and interpretation of the data (Wolstenholme 1990).

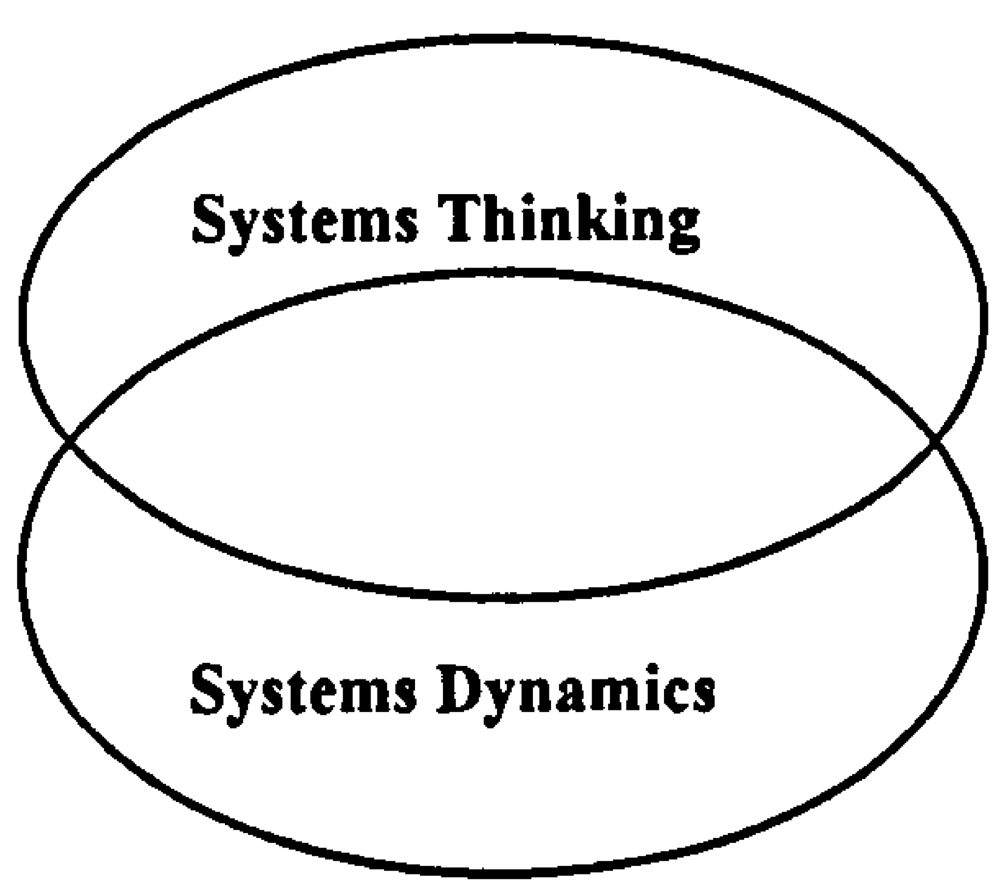
The output of that action was a model to estimate and assess the construction and demolition debris trail. It is a dynamic model with different variables and behaviours leading to different scenarios. It is an iterative process resulting in a simulation model. This is the area where system dynamics is appropriate. The word dynamic implies constant change over time (Cover 1996:15). Environmental systems are dynamic systems and changes in a system take place when that system is subject to a disturbance (White, Mottershed, and Harrison 1993:510).

System dynamics uses diagrams which represent a quantity or a relationship or a plan demonstrating the form or workings of an object or system (Oxford Dictionary 1995). The use of systems dynamics diagrams to structure and analyse ill defined or insufficient known situations can be considered as a free standing methodology. It has been developed as an alternative to science-based approaches and has much in common with soft systems problem solving methodology (Wolstenholme 1990:3). Checkland (1991:7) writing from the soft systems position made the same observation. He observed that the problem situation can be modelled by the different but appropriate systems. Each one established a "root definition" from which a model was made conceptualising a human activity system.

The interrelationship and interactivity between two methodologies has been studied by Eden, Jones, and Sims (1983). They presented some case studies in management. In these studies the use of both methodologies led to more appropriate solutions. They demonstrated the contention that the two methodologies can be used synergetically addressing the same research question. That work suggested that the research questions in this research could be satisfactorily addressed by combining the two methodologies.

The relationship between the two fields can be illustrated by using a Venn diagram as demonstrated by Cover (1996:10) and illustrated in figure 6.11.

Figure 6.11 – Venn diagram of System Thinking and System Dynamics

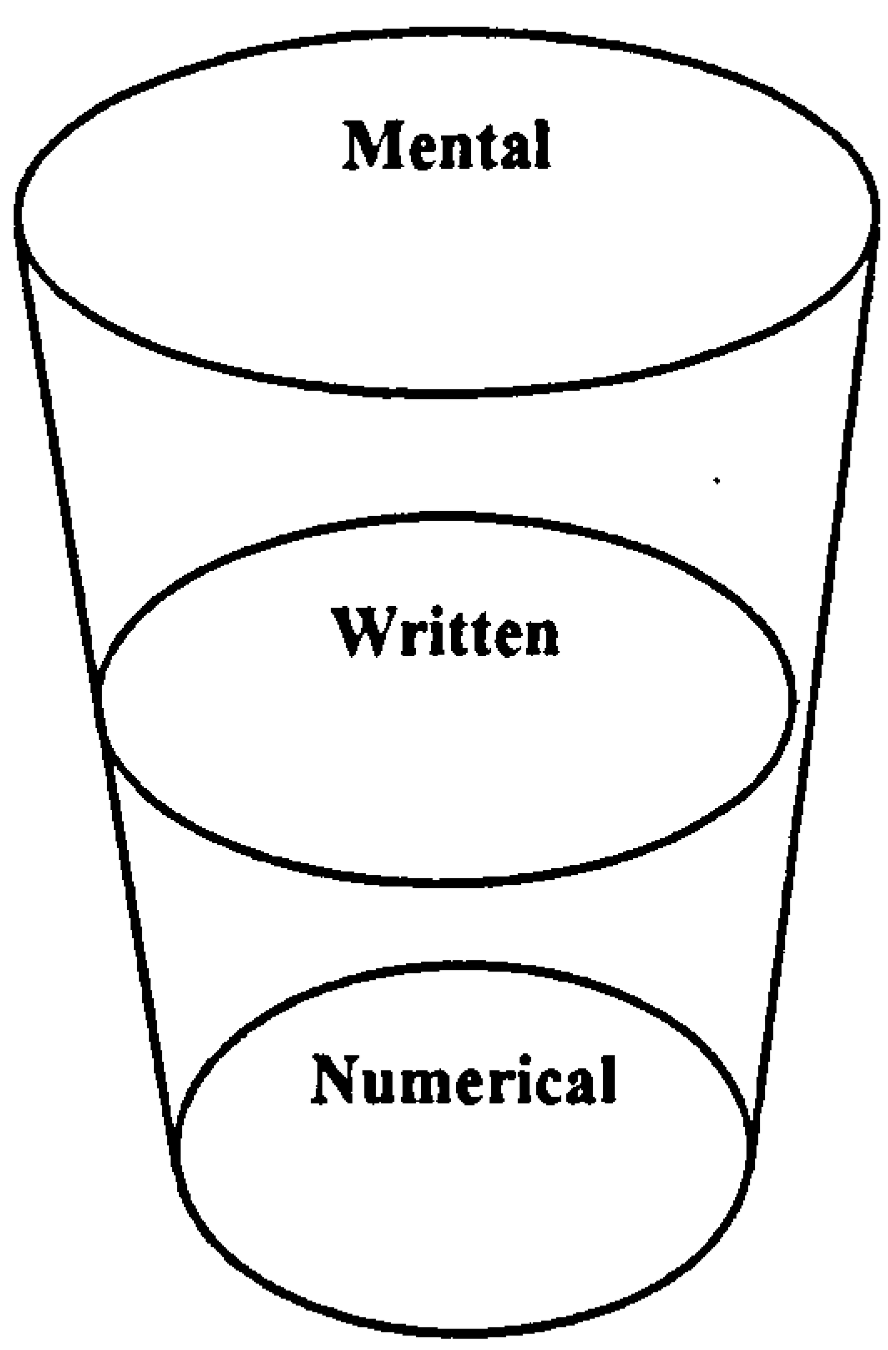


Source: Cover 1996.

The diagram highlights the overlap and demonstrates the commonality of the two fields. Systems thinking methodology is a powerful tool that illustrates a researcher's mental model of the world and enhances perception. The human mind has many attributes but it has troubles in relating effects to causes, especially when the two are not close in time. It is not good at dynamic simulation (Cover 1996:10). This is not surprising when one realises that simulating the most complex problems is of similar difficulty to solving a one hundredth order differential equation.

Forrester, quoted by Cover (1996:12), used a funnel to illustrate these concepts. His illustration is presented in Figure 6.12

Figure 6.12 – Funnel representation of our mental information.



Source: Cover 1996:12.

The top of the funnel represents our mental information, that is, everything we carry in our heads. This information database is the largest and richest that is available to us. Next in the hierarchy is the written and picture database. It represents all the information we have on paper or stored electronically. This database may be smaller by a factor of a hundred or even a thousand and represents a far less rich picture that our mental database. Finally, there is a numerical database, representing all information that is stored as numbers. This degrades the amount and richness of the information by another hundred or thousand fold. Clearly the richest source of information about a situation is at the top of the funnel, in the mental database. That information needs to be extracted and entered into a computer simulation to solve problems of dynamic complexity (Cover 1996).

The construction and demolition waste stream is a social construct and a dynamic system of great complexity. It is an environmental system appropriately studied using soft systems and systems dynamics theory.

SECTION 4: PREPARING DATA COLLECTING

Introduction

Data collection is at the core of the research. The value of the data can be maximised if the construct validity and reliability of the data in the case studies are properly established (Yin 1994). The three processes to establish that construct validity and reliability are:

1 - Use multiple sources of evidence. This enables triangulation and the development of converging lines of inquiry. Patton (1987) suggests four types of triangulation:

a) Of data sources - data triangulation.

b) Among different evaluators - investigator triangulation.

c) Of perspectives on the same data set - theory triangulation.

d) Of methods - methodological triangulation.

The time factor will limit the amount of cross-checking possible. In an extensive study more than one method of data collecting should be used. This multi-method approach is described in Open University course E811 as:

> - Cross checking the existence of certain phenomena and the veracity of individual accounts by gathering data from a number of informants and a number of sources and subsequently comparing and contrasting one account with another in order to produce as full and balanced a study as possible (Bell 1995:64).

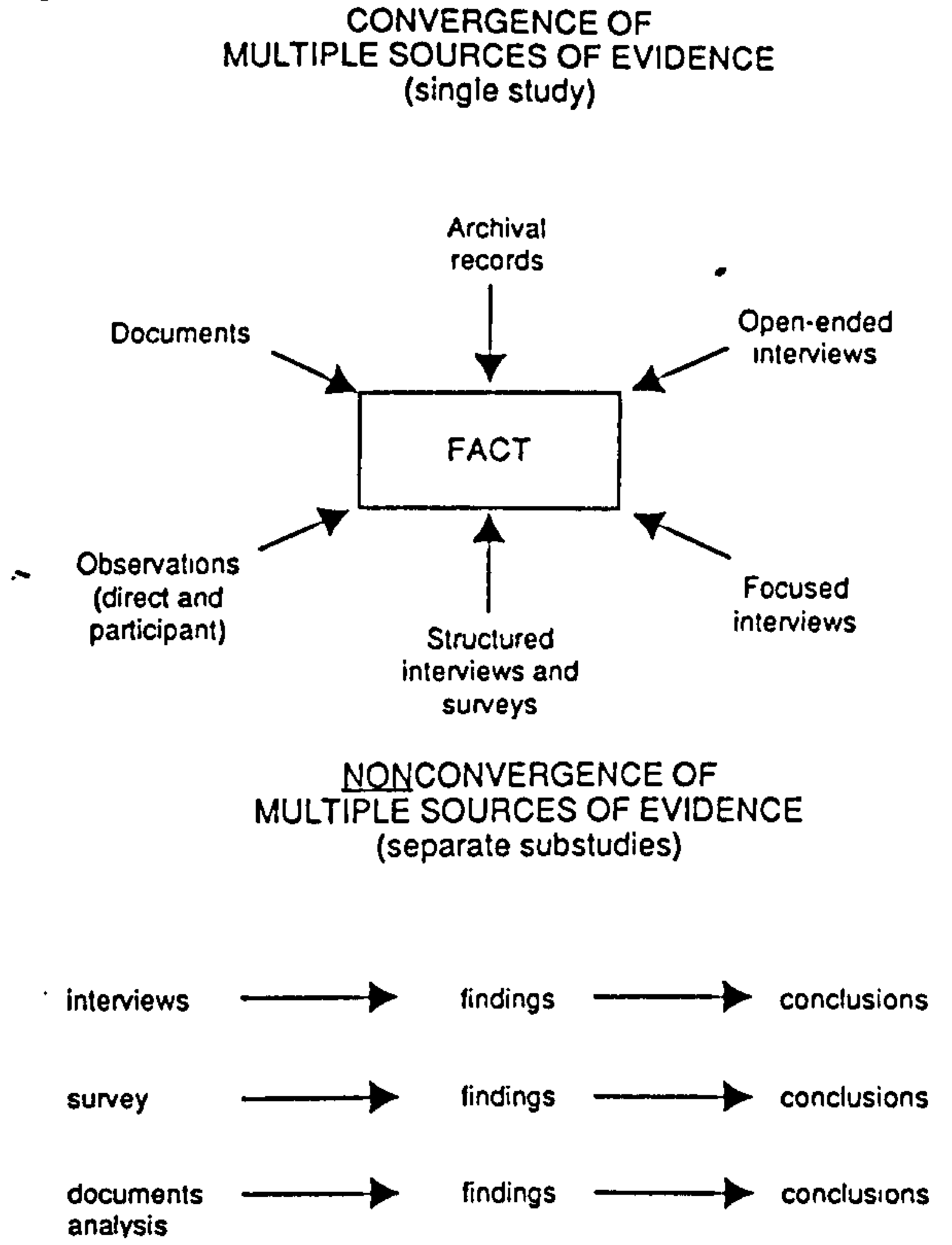
2 - Creation of a case study database. This process deals with the way of organising and documenting the data collected for many case studies. In this research the case study strategy has drawn from practices used with other strategies, in which information is generally derived from separate sources. They are:

a) the data or evidentiary base.

b) the report of the investigator, whether in article, report, or book form.

3) - Maintain a chain of evidence. This process increases reliability and allows the researcher and an external observer to follow the derivation of any evidence from initial research questions to ultimate case study conclusions.

Figure 6.13 - Convergence and non convergence of multinle source of evidence



Source: Cosmos Corporation (Yin 1994:Fig 4.2:93).

Figure 6.13 from Yin (1994) presents the distinction between two conditions. One, the upper portion, shows the multiple sources of evidence triangulated to arrive at the characteristics of an entity. The lower portion shows the multiple sources treated in a linear fashion and not triangulated leading to a set of discrete conclusions. With triangulation, the potential problems of construct validity are addressed. The multiple sources of evidence essentially provide multiple measures of the same phenomena. According to Yin, Batman, and Moore (1983) an analysis of case study methods found that case studies using multiple source of evidence were rated more highly in terms of their overall quality, than those that relied only on a single source of information.

In this research data was collected from several case studies. Other sources of evidence were extracted from the proceedings of international conferences, scientific and technical reports, technical guides and other reliable material available from European Union (Morgan and Argus 1995).

Training and preparation

Often a case study investigation must rely on multiple investigations. This is because a sample case study may call for intensive data collection at the same site, requiring a "team" of investigators. It may be a case study which involves multiple case studies requiring different persons to cover each site or to rotate to the different sites. It may also be a combination of the first two conditions. This involvement of a team, sometimes with individuals changing roles during the process, necessitates a training programme.

Every person involved in the research must be sufficiently briefed on the project to enable them to satisfactorily carry out their role. They need to know the objectives and to understand the approach to the research. They need a clear understanding of the contribution that the case studies will make to achieving the objectives of the research. They need a clear picture of the roles and responsibilities of the personnel involved in the project and their own individual roles and responsibilities.

According to Yin (1994) training for a case study investigation actually begins with briefing on the definition of the problem being studied and the development of the case study design. Sometimes members of the research team may not have participated in the initial problem definition or research design phases of a study. In these conditions the briefing of those personnel will additionally include the history of the project enabling them to fit easily into the team at the latter phase.

A seminar must be one of the best forms of training and much better than a rote instrument. It gives a richer picture. Yin (1994: 61) stated it must, typically, cover all phases of the planned case study investigation, including readings on the subject matter, the theoretical issues that led to the case study design, the case study methods and tactics. The goal of the training is to give all the participants in the fieldwork and global research an understanding of the basic concepts, terminology and issues relevant to the study. Yin (1994:61) suggests that a training session must address the reason for the research and what evidence is being sought. From that position the detailed issues can be addressed. They are:

1 – The purpose of case studies.

2 - Field assignments.

3 - Tasks for case studies.

4 - The training reminders. The aide memoir of record keeping and procedures for consistency.

The training seminars undertaken and monitored for this research will be discussed in detail in later chapters. They were used, among other things, to introduce the case study protocol. According to Yin (1994) a case study protocol is desirable in all situations but essential in a multi-case study design. In this research the approach to collecting the data was via multiple holistic case studies. The data was collected from different buildings in different locations with different characteristics. The data was collected by actors who had not previously been involved in data collection.

The case study protocol contains the procedures and general rules that should be followed in undertaking the case study. It is a major instrument in guiding the researcher in carrying out the case study data collection and in ensuring reliability. Reliability is concerned with the consistency of the research. The protocol must have a structure that describes the purpose and, according to Yin (1994), may have three main parts. The first part contains the procedures, with sections on the initial scheduling of field visits, determination of persons to be interviewed and sources of information and training. The second part should contain the case study protocol and questions to be addressed. The final part should contain the procedures for analysis and the structure of the case study reports.

In this research a discussion on the draft protocol was a major agenda item of the pilot case study training seminar.

The Pilot Case Study

A pilot study is a small scale study to test the research design and methodology proposed for a later major study. The pilot study is the final preparation for data collection, and it helps to redefine the data collection plans with respect to both the contents of data and the procedures to be followed.

According to Yin (1994), the pilot study is not a pre test. It assists the investigator to develop relevant lines of questions, providing some conceptual clarification. For this reason, three issues must be carefully considered. The issues concern the selection of the pilot cases, the nature of the inquiry and the nature of the reports. Generally the issues of concern to the selection of pilot cases are convenience, access and geographic proximity. Addressing the nature of the inquiry, the pilot case must provide considerable insight into the basic issues being studied, about relevant field questions and about the logistics of the field inquiry. Finally, the pilot study report must be written clearly, explicitly about the lessons learned for both research design and field procedures (Yin 1994: 76).

According to Maxwell (1996), pilot studies serve some of the same functions as prior research, but they can be focused more precisely on the researchers own concerns and theories. They can be designed specifically to test ideas or methods and explore their implications or to inductively develop grounded theory. This same idea was developed by Ligh, Singer and Willet (1990:212 –213) in their work on higher education. They assert that "many features of their design could not be determined without prior exploratory research" and no design is ever so complete that it cannot be improved by a prior small-scale exploratory study. "Pilot studies are almost always worth the time and effort. Carry out a pilot study if any facet of your design needs clarification". As a result of a pilot study, changes could be made to the instructions, the sample and the contents of the questions, working or sequence (Edwards and Talbot 1996). In some cases, pilot studies assist decisions made about data analysis, and design of postal questionnaires. Edwards and Talbot (1996) view pilot studies as usually "a test-run of a data collection instrument, for example a questionnaire or interview schedule. It allows a researcher to modify any flows in methodology prior to undertaking a major study. The study is carried out on a small pilot sample of people from the population under scrutiny. It should not draw on the sample to be used in the major study". It is an especially useful form of anticipation and an excellent means by which to determine the sample size necessary to discover significant differences among experimental treatments (Locke, Spirduso, and Silverman 1993).

Two main issues are very important in a pilot study (Yin 1994):

1- It contributes to reminds the investigator what the case study is about.

2 - It forces the researcher to anticipate several problems including that of how the case study might be completed.

Sources of evidence

According to Yin (1994) collecting evidence for case studies may come from six sources of evidence as following:

- Documents.

- Archival records.
- Interviews.
- Direct observation.
- Participant observation.
- Physical artefacts.

However, that the last of source of evidence could be extended to films, photographs, videotapes, "street" ethnography, which depend of the real world studied. In addition to the attention to these individual sources and the ways of collecting data, three essential principles must be followed:

- The incorporation of these principles into a case study in investigation increases the quality substantially (Yin 1994). Multiple source of evidence are necessary to gain access to firstly, the project level data and secondly to the variation itself (McDermott 1995). The case study approach does not allow statistical generalisation. Case studies do, however, allow analytical generalisation, that is to generalise a particular set of results to some broader theory rather than to a larger population (Yin 1994). In order to produce analytical generalisations, it is necessary to replicate case studies, where the theory would predict that similar results should occur.

This is one reason for adopting a multi case study design. According to Yin (1994), Figure 6.14 presents a useful overview of the six major sources of evidence considers their comparative strengths and weaknesses.

Figure 6.14 – Six Sources of Evidence, strengths and weaknesses

Source of Evidence	Strengths	Weaknesses
Documentation	• stable—can be reviewed repeatedly • unobtrusive—not created as a result of the case study • exact—contains exact names, references, and details of an event • broad coverage—long span of time, many events, and many settings	• retrievability—can be low • biased selectivity, if collection is incomplete • reporting bias—reflects (unknown) bias of author • access—may be deliberately blocked
Archival Records	• *[Same as above for documentation]* • precise and quantitative	• *[Same as above for documentation]* • accessibility due to privacy reasons
Interviews	• targeted—focuses directly on case study topic • insightful—provides perceived causal inferences	• bias due to poorly constructed questions • response bias • inaccuracies due to poor recall • reflexivity—interviewee gives what interviewer wants to hear
Direct Observations	• reality—covers events in real time • contextual—covers context of event	• time-consuming • selectivity—unless broad coverage • reflexivity—event may proceed differently because it is being observed • cost—hours needed by human observers
Participant-Observation	• *[Same as above for direct observations]* • insightful into interpersonal behavior and motives	• *[Same as above for direct observations]* • bias due to investigator's manipulation of events
Physical Artifacts	• insightful into cultural features • insightful into technical operations	• selectivity • availability

Source: Yin 1994:80.

SUMMARY

This Chapter has presented the methodologies used the research which was overviewed in Chapter 1. Chapter 1 presented the research structure, aims and objectives. The methodologies are presented explained and justified in the context of the research. The explanation also has the objective of contributing to an understanding of how, when and why these different but complementary approaches work together. They demonstrate the relationship between the real world and the fieldwork.

The case study methodology provides the environment for the data collection. The soft system thinking methodology provides the framework for developing the conceptual mental model and allowing comparison with the real world. It facilitates an iterative process preparing further testing and comparison with the real world. The systems dynamics approach is necessary to understand the integrated interaction of the entities in a dynamic system. This is a characteristic of every environmental and sustainable system. Particularly attention was paid to the characteristics and preparation of the case study. The methodologies to collect the specific data were designed with a view to their possible application to the future research on Lisbon area construction and demolition case studies.

CHAPTER 7:

INTERPRETING INTERNATIONAL CASE STUDIES RESULTS TOWARDS A DYNAMIC MODEL CONSTRUCTION.

"The grand aim of all science is to cover the greatest number of empirical facts by logical deduction from the smallest number of hypotheses or axioms"

(Einstein 1950)

INTRODUCTION

This Chapter reports on case studies in some six countries with the aim of informing and guiding the analysis of the Lisbon case studies and the studies from

ADEME (1998). This knowledge should assist in the definition of the dynamic construction and demolition model. The lack of data on the construction and demolition waste stream in Portugal is significant and hinders the development of a National strategy. This situation has been highlighted in a series of European Union construction and demolition meetings. The fifty-five recommendations emanating from those meetings were reported by Morgan and Argus (1995). The Directorate General XI of the European Union has also commented on this situation and on the importance of the information in the development of a national strategy (Warmer Bulletin nº 47 1996). It supports the need to analyse other experiences and to develop a clear understanding of the characteristics of the waste stream and the implications of lack of data. It has conditioned the approach to this study.

A report by the French Agency ADEME (1998) also addressed these issues. In was a four volume report entitled "Guide to the waste from construction sites", subtitled "Knowledge for action". It emphasised the need for accurate data as a precondition to the understanding and development of models of the construction waste stream.

Section 1 of the Chapter reviews the data and information from the selected six case studies. The review has two foci. One is related to the "hard" data from the fieldwork, the other is focused on the "soft" data. The "soft" data deals with the attitudes and behaviour of the actors involved. Section 2 is focused on reflecting on the lessons of those studies. Some of the information obtained conditioned the development of the Lisbon case studies and other information and data fed directly into the conceptualisation and development of the dynamic model.

SECTION 1: CASE STUDIES REPORTED

The Presidio of S. Francisco Demolition and Recycling. Building 901 Programme (USA)

The first case study reported concerned the feasibility of the deconstruction process in terms of the technical and economic issues. It highlighted the importance of the preliminary waste survey in determining the appropriate demolition methodology. The survey was required to reveal the hazardous materials present in the structure. That information was needed to determine the appropriate technique for the removal and treatment of those materials. It concluded that selective demolition techniques were appropriate but there were financial costs.

The case study was chosen due to its importance and the lessons that could be learned from selective demolition in the context of sustainable construction. The case study was related to a demonstration project in Education for Sustainability. The project was initiated, within an agenda for action, at the "National Forum on Partnerships Education about the Environment" (NFPSEE 1996) held at Presidio S. Francisco in the Autumn of 1994. The role of the Presidio global project demonstrating approaches, infrastructures and new attitudes towards sustainability was a key project in the forum's agenda.

A - Location

The Presidio of S. Francisco, is located on the Northern point of S. Francisco Peninsula at the South end of the Golden Gate Bridge, and dissected by Routes 101 and 1 at S. Francisco, United States of America. This former military post is now part of the Golden Gate National Park. It encompasses 1.840 acres of land with 870 buildings, a research facility, a golf course and a national cemetery (CIWMB 1996).

B - Site history and development

The 870 buildings on site represent over 57,6 x104 m2, 570 has landmark status, and the remaining 200 buildings are scheduled for demolition. The plan was to demolish 43 of the 200 buildings in the year 1996. The closure and redevelopment Plan for the Presidio proposed that the area be transformed into a working laboratory to create models of environmental sustainability. The models could then be transferred world-wide. Guided by the sustainability agenda, the building demolition contract incorporated recycling clauses. However the contract did not require a high percentage of materials to be recycled. The mechanical demolition proposed for the first stage of demolition allowed for the minimum recovery but prevented the salvaging of materials for high order uses. The result was that two buildings, 283 and 901, were selected from the demolition contract and subject to demolition processes to increase recycling rates. Building 901 is the subject of the case study reviewed. The building was constructed in 1942 as a "temporary" wartime structure. It was a single storey timber framed building with floor dimensions of approximately 15.00 x 33.75 m. It was constructed almost entirely of wood, with wood flooring on concrete foundations, and wood roofing boards covered with asphalt felt shingles.

The process of deconstruction of the building was designed to maximise the salvage and recycle as much of the released materials as possible. The resulting process of deconstruction had a great deal of hand dismantling and material salvage. A consortium of three salvaging groups performed the deconstruction. The deconstruction process showed that there could be a great increase in the amount of materials salvaged using "soft" demolition techniques whilst maintaining operational costs competitive with traditional demolition techniques. The salvaged materials were sold to the highest bidder.

C - Dismantling and Demolition

Four visits before and during the deconstruction works were made in order to develop a waste audit. The first visit from staff of the California Integrated Waste Management Board (CIWMB) was done to document the deconstruction and salvaging techniques used on the building. The remediation for the removal of some hazardous materials such as asbestos and lead based paint was the first priority. All the components were stripped down and dismantled with care throughout the deconstruction process. The work was completed in 15 days against an original estimate of four weeks. The removal of roofing materials, windows, interior walls was done carefully and the materials were stored on site. The materials were then auctioned at the site to reduce transportation costs and transferred them from the demolition contract. Finally, the floor materials were removed and the concrete substructure was broken up and removed by a separate contractor.

D - Waste stream generated

The principal objective of the demolition process was to prove that deconstruction with a dismantling and demolition phase could be carefully prepared and executed and could be economic. The main problem found in dismantling was the removal of nails and the metal connectors linking the interior walls. This proved extremely difficult to do whilst minimising the damage to the timber components. A final summary of the amounts of the materials released from Building 901 was made, by timber member/species, dimensions; volume and volume recovered (% recovered) and is shown in Table 7.1.

Table 7.1 – Wood materials recovered from Building 901

Member/Species	Volume Recovered (% Recovered)
Roof Plank - (T&G)pine-Fir	(25%) (50%)
Wall Plank/ Ponderosa pine	(90%) (95%)
LDF Wall, Peak Liner/Unk.	(0%)
Firring/Port Orford Dedar	(5%)
Interior Ply/ Doug Fir	(95%) (100%)
Non-Struct. Framing/Doug Fir	(90%)
Ridge/Purlin/Doug Fir	(70%)
Rafter/Doug Fir	(95%) (95%)
Cross-tie, Stud/Doug Fir	(95%)
Post/Doug Fir	(100%) (99%)
Brace/ Doug Fir	(90%)
Stud, Ceiling Joist/Fir-Pine	(90%)
Stud, Ceiling /Joist/Redwood	(90%)
Siding/Redwood	(75%)
Ext. Deck, Joist, Facia/S-P-F	(0%) (99%)
Flooring (T & G)/Doug Fir	(100%)
Flooring (T & G)/Port Orford Cedar	(99%)
Floor Joist/Doug Fir	(99%)
Still/Pine	(90%)
Total	(87%)

Source: CIWMB 1998

In this case study, 85 % of the wood was recovered and half of the wood recovered was sold on site. It was estimated that 15 % of the timber recovered was found to be unusable or degraded below recycling quality by the dismantling process.

The deconstruction of Building 901 took approximately 1000 man-hours. The project economics are shown below:

Costs:

- Labour costs (1000 hours)........................33.053
- Logistical cost of equipment
  Hauling and removal of concrete..............11.938
- Administrative costs................................ 12.604

TOTAL 57.595 (Euros)

Income:

- Greater contract return...............................16.800

(This was the sum saved by omitting the building from the original demolition contract)

- National Park Service................................15.000

(This sum was a grant from the National Park Service to foster the hand deconstruction project and help develop future similar projects)

- Sales (wood, windows, etc.).......................30.155

TOTAL 61.955 (Euros)

These figures show a net profit on the project of 3.360 Euros. However closer inspection by comparing the direct costs (57.595 Euros) and direct commercial income (30.155 Euros) of the project results in a cost (loss) of 27.440 Euros. This compares with a cost of 16.800 Euros for demolition without attempting to maximise recovery of materials.

E - Summary

Each deconstruction project is unique. The overall project feasibility had to be evaluated in the context of the materials that are generated by the demolition, the labour costs and time frames necessary to release the materials and value and robustness of the local market into which the material are sold. This project yielded some general conclusions that can be applied to any proposed project. They are:

1 – Cost/Benefit. This project shows that hand deconstruction can be performed but at rates which are not competitive with mechanised demolition. The recovering valuable material, preserving natural resources and conserving available landfill space is at a cost to the demolition contract. This is an issue which is at the core of the difficulties in encouraging the move to maximising resource recovery.

2 – Worker Experience. The workers demonstrated an ability to salvage a high percentage of reusable material in a short time frame.This was achieve within reasonable cost limits.

3 – Define rate Recovery. When it is intended to reuse or recycle a high percentage of materials generated from the process a minimum rate of recovery should be specified. It is also necessary to define terms such as "recover". This project salvaged a high percentage of timber.

4 – Time Frames. Deconstruction or "soft demolition" techniques generally take longer than mechanised demolition operations. In order to salvage building materials, additional time is usually needed.

There are two factors of this project that demonstrate their influence on the overall profitability of the project. The first factor involves contract conditions. They were amended for the deconstruction of building 901 to include the maximisation of waste recovery at a net cost to the contract of 10.640 Euros. This is the difference between the net cost of the no recovery contract (16.800 Euros) and the maximised recovery contract (27.440 Euros). The second factor that influenced the overall economics of the project was the price gained for the recovered materials in the market (30.155 Euros). That price was highly market dependant and very volatile.

Ontario Residential Home Deconstruction Case Study (Canada)

The second case study comes from Canada which has significant expertise and knowledge in sustainable construction. The case study highlighted the necessity to begin a deconstruction project with a waste survey. It demonstrated the economic feasibility of the project under appropriate conditions and also the need for training.

A - Location

This case study was located in Ontario in Canada. The project involved the deconstruction of three buildings and a residential home, dating from the early 19th century.

B - Site history

The buildings deconstructed were a four-storey house; a two-storey barn and a one storey detached garage. The three buildings had a total area of 899.8 square metres. The work was carried out in November 1996. The goal of the project was to create a "standard" aimed at directing contractors towards more environmental and sustainable practices. At the outset the project was not expected to make a profit as the contractor and his employees did not have experience of this specific work. It was considered as a pilot project.

C - Dismantling and Demolition

The deconstruction project began with a waste survey conducted before the deconstruction began. This process created an estimate of the waste which would be expected to be generated. The process used for the deconstruction was basically the reverse of the construction process. Six employees working with hand tools provided the required labour. Activities commenced with the windows, doors, finishings and furnishings, being salvaged. The roof was removed, interior walls were dismantled, followed by the exterior walls and the floor system. This process was repeated for each floor.

D - Waste stream generated

Wood made up the largest portion of the waste. Due to its potential for reuse and high market value, it made up the largest portion of the sales. Therefore care was taken to minimise damage during the demolition process. Doors, windows and finishes were also easily sellable. Concrete made up the highest percentage of the waste, by weight, but generated the lowest amount of revenue. The concrete patio stones were sold and a road building contractor crushed the remainder of the concrete for roadbed material.

Table 7.2 presents the waste stream generated in terms of material category, revenues generated, and information about the recycling or reuse possibilities due the quality of the materials. The reuse of materials accounted for 60.5 % of the achieved waste diversion and 95.5 % of the total revenues generated by the project. Another 30.5 % of the material was recycled and these generated 4.5 % of the total revenue.

Table 7.2 – Project statistics (Euros). Source: Deconstruction of a Residential Home Case Study 1996, Ontario, Canada

Material Category	REVENUE	RECYCLE	REUSE
Wood	5.020.00	Yes	Yes
Doors & Windows	1,810.00	Yes	No
Finishes	800.00	Yes	No
Furnishings	640,00	Yes	No
Metals	520.00	Yes	Yes
Mechanical	340.00	Yes	No
Insulation	320.00	Yes	No
Electrical	310.00	Yes	No
Concrete	240.00	Yes	Yes
Roof Membrane		No	Yes

Source: C & D Waste Web 1996.

E - Summary

The total cost of the project was 44.000 Euros. However it did not represent a typical demolition cost. The house had suffered from considerable vandalism which had prevented the recovery of many materials. The demolition contractor was not familiar with the deconstruction techniques and there was a learning curve which slowed the process. 5,000 Euros was allocated to document the waste generated and to record the rate of diversion. These costs were off set by the 10,000 Euros in revenues generated from the sale of reusable materials. The final analysis of the project showed the project expenditures to be 2.000 Euros greater than traditional demolition costs. However, it should be noted that this added cost can be attributed to the inexperience of the work crew, and the lack of adequate quality of materials for sale in the second use markets.

Tokyo Residential Buildings Demolition Case Study (Japan)

The third case study reviewed is a Japanese case study. It identified six main obstructive factors to the movement towards sustainable construction. This work also highlighted the necessity of adopting alternative building methods to achieve sustainability. The case study dealt with the demolition of Japanese residential buildings and how materials from dismantling and demolition are discarded or reused.

A - Location

Six residential buildings located in Tokyo, the Japanese capital, were selected for the field surveys (Yashiro 1994:581- 590). One building, building A, was a block of flats composed of 10 dwelling units, and the other buildings B,C,D,E and F, were detached houses.

B - Site history and development

Table 7.3 presents a description of the buildings that were targeted for demolition. Among them, building A and B were neighbouring buildings and were demolished successively by the same contractor. Building A and B were conventional post and beam structures. The others were prefabricated houses where components were prefabricated in a factory. Buildings A, B, C and D were dismantled and demolished in pieces. Buildings E and F were box unit structures and were reconstructed on other sites by reassembling the box units.

In the survey the authors and associates observed and recorded all processes of demolition on formatted survey sheets, took videotapes and photographs of the entire process, and interviewed the site foreman.

Table 7.3 - Description of target demolished buildings

	Structure	n. of floors	Total floor area (m2)	Mode of disassembling
A	Tomber frame (post and beam)	2	322.50	Demilition
B	Tomber frame (post and beam)	2	134.46	Demolition
C	Prefabricated wooden panel	2	277.96	Demolition
D	Prefabricated light weight steel panel	2	237.53	Demolition
E	Prefabricated light weight steel box unit	2	214.18	Re- assembling in other site
B	Prefabricated wooden box unit	2	235.87	Re- assembling in other site

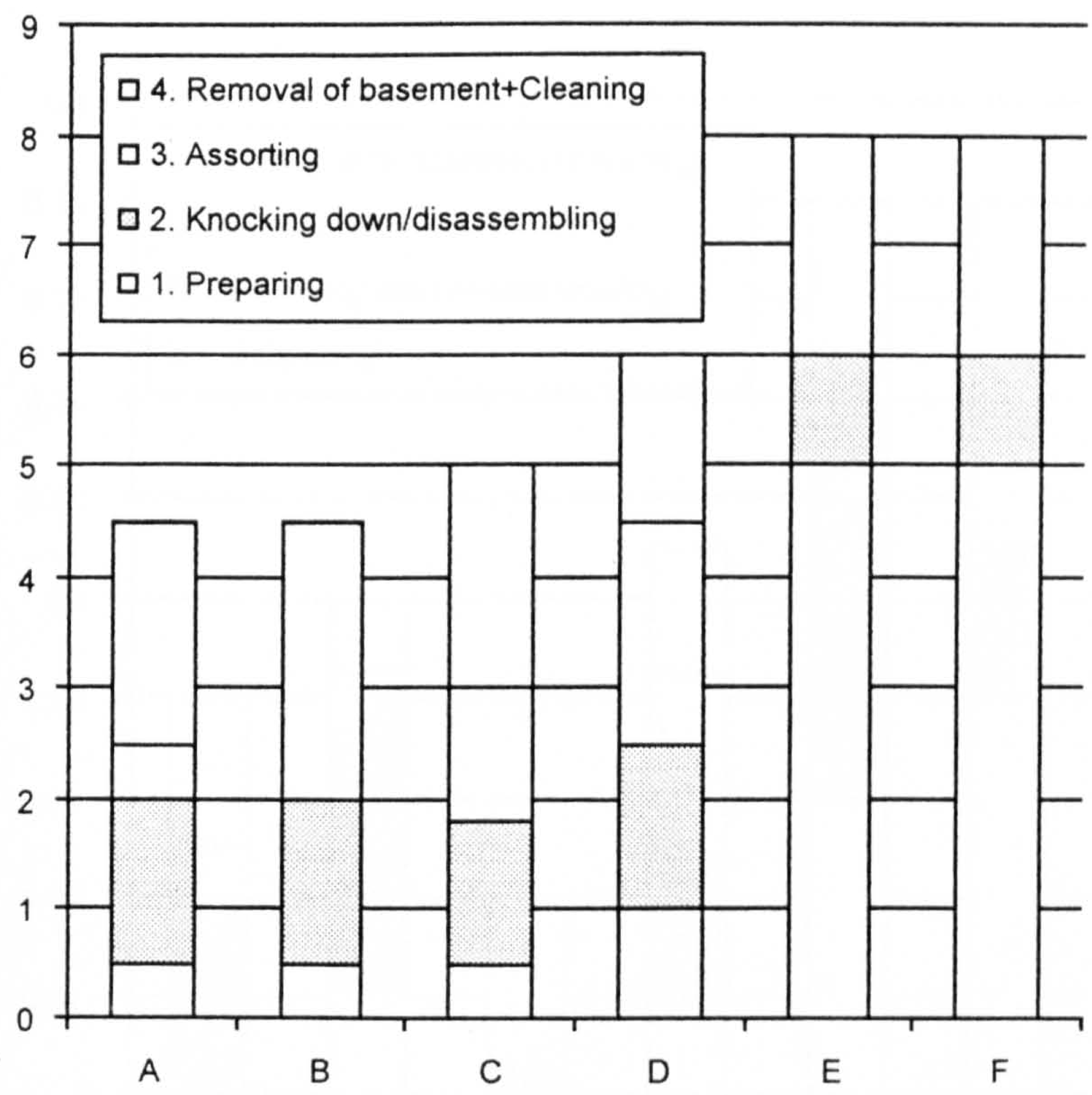
Source: Yashiro 1994: Paper 8: Table 1: 2.

C - Dismantling and Demolition

The process of dismantling and demolition was recorded on video and photographs through the entire process. Data was also recorded on formatted sheets. Yashiro (1994) sometimes identified the dismantling phase as a different phase from the demolition one. On other occasions the authors referred to demolition as include dismantling. This caused confusion but was overcome with care. The survey focused on the period of dismantling, number of site operatives required for the demolition work and volume of materials released.

Figure 7.1 shows that for buildings E and F, the reassembled units required more time for demolition and dismantling, than buildings A and B, the conventional post and beam structures. Figure 7.2 correlates the number of site operatives to the level of demolition in terms of man/day per square metre demolished. The time taken to dismantle buildings E and F was greater than that for the other four buildings.

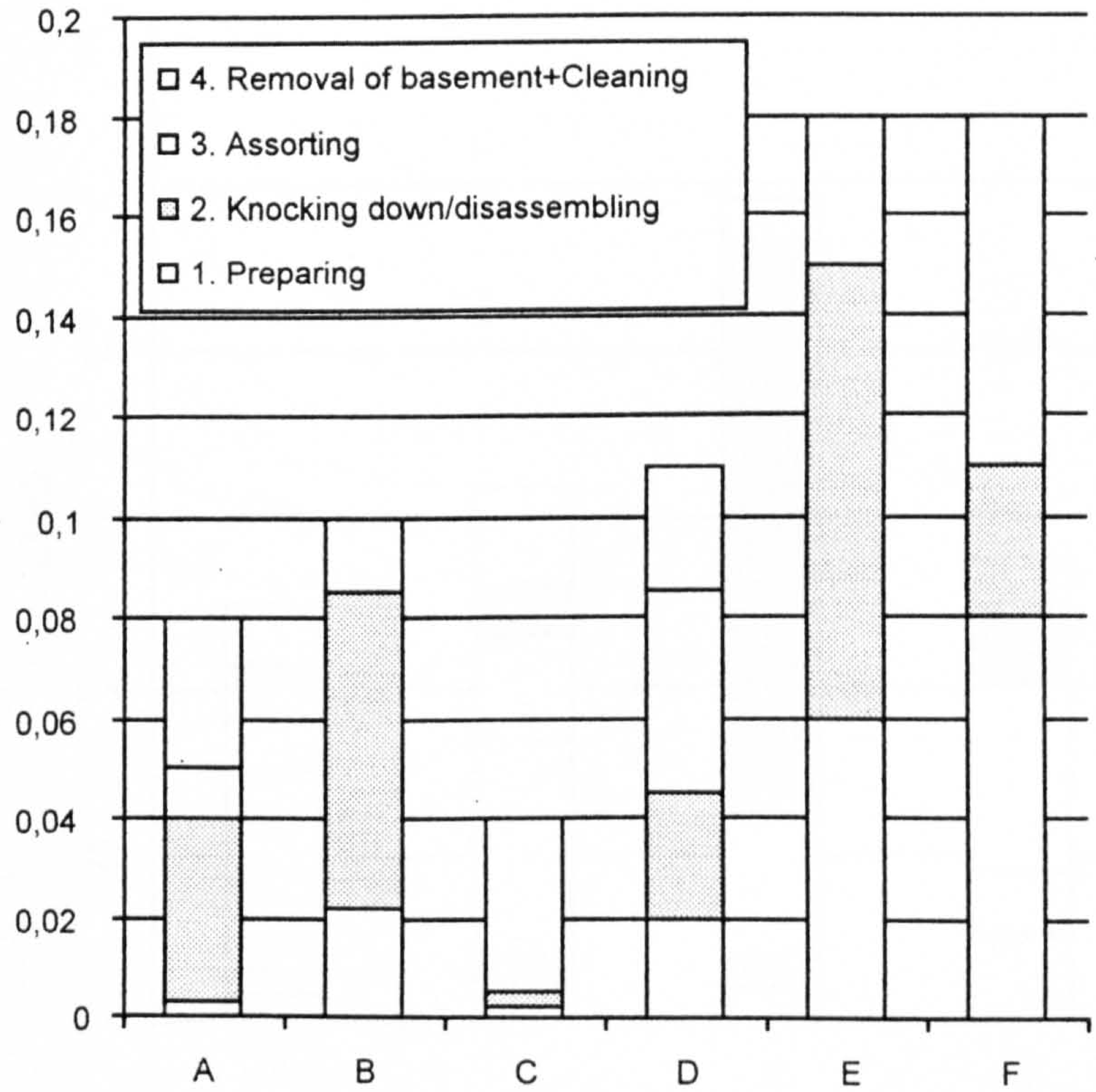
Figure 7.1 – The period for demolition work



Source: Yashiro 1994: Paper 8:Fig. 3:3.

For buildings E and F the stage of preparing and disassembling the buildings into component units took more labour, while in buildings A, B, C and D the stage of preparation involved less site operative time. Most of the manpower was used for demolition, disassembling and sorting the materials. These activities are closely related and the sorting was done in parallel with the demolition and disassembly.

Figure 7.2 - The quantity site operatives for demolition work

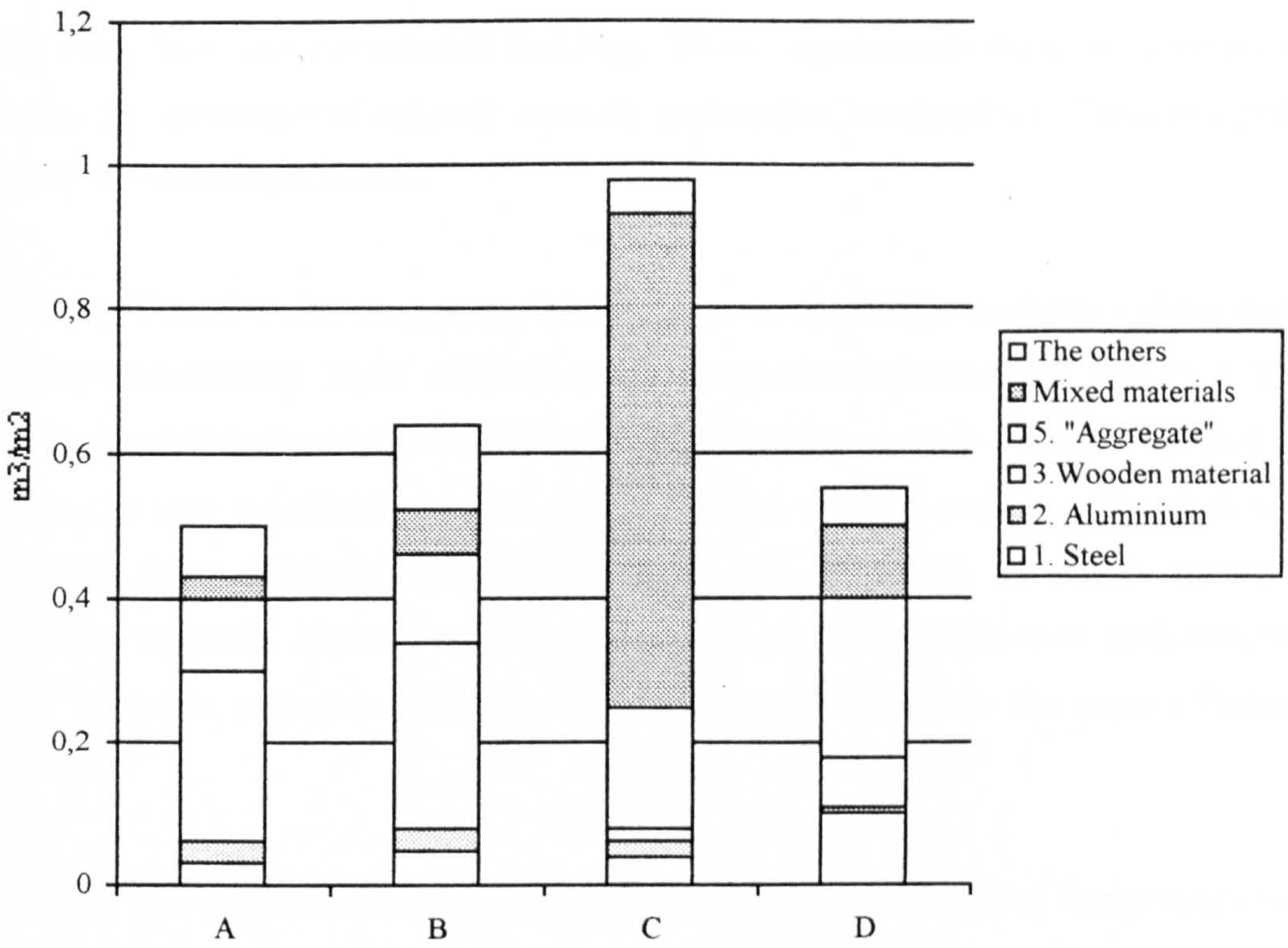


Source: Yashiro 1994:Paper 8: Fig. 4:4.

D - Waste stream generated

Yashiro (1994) considered two types of disassembly works. The first was the demolition procedures associated with buildings A, B and C. This was done with pincer crushing machines. For those which were to be reassembled it was necessary to use lorries with a crane. Figure 7.3 gives the information about the volume of waste from demolishing buildings (m3/m2) and the nature of the waste stream.

Figure 7.3 – Volume of building waste from demolished buildings (m3/m2)



Source: Yashiro 1994: Paper 8: Fig. 5: 7.

The Figure 7.3 shows the amount of removed material (per m2). Building C, a prefabricated wooden panel structure building, produced the largest volume of material removed from site. It was almost double the volume of the other buildings. The analysis revealed that the materials from building C showed a high content of mixed materials suggesting that the sorting process was less satisfactory for this building than for the others. Figure 7.3 suggests that poor sorting results in decreased density of material carried by lorries, and an increased volume of material removed from site.

E – Summary

Yashiro (1994) point out that there are some impediments to the reuse of the waste from demolished residential buildings. These impediments must be overcome in moving the construction industry towards sustainable construction. Yashiro (1994) identify six main impediments:

1 – The difficulty in applying labour intensive demolition methods. Labour costs are very expensive in Japan which is common to other industrialised countries. The labour intensive deconstruction of timber frame structures used to be normal procedure resulting in easy re-utilisation of the timber. Skilled workers available for demolition work have been decreasing creating shortages and difficulties for labour intensive demolition methods. Instead, rapid demolition by crushing machine is replacing the labour intensive processes and reducing the materials available for reuse (Yashiro 1994:7).

2 – The adoption of non-reversible jointing details for building components is a problem. Most recent component jointing technologies are not reversible resulting in damage to the components on deconstruction. Historically Japanese traditional timber structural members were easy to connect and disconnect allowing the components to be reused in an undamaged state.

3 – The adoption of combined materials and components. Recent building methods combine different materials to form components, reinforced concrete for example, these technologies increase the difficulty in sorting the waste during demolition.

4 – The use of crushing machines. All kinds of materials are mixed together by crushing machines. This increases the difficulty and the cost of sorting the resultant waste pile into separated material streams suitable for recycling.

5 - Lack of economic incentives. Economical motivation for promoting re-utilisation does not exist. The low cost of disposal and the low price obtained for

reusable or recyclable materials is a disincentive to the re-utilisation of building waste (Yashiro 1994:8).

6 – Lack of reliable quality and quantity. The reusable and recyclable materials are of uncertain quality and their supply is unstable.

When considering the necessity of constraining, production of an enormous quantity of waste from demolished buildings in Japan. The Yashiro (1994) consider that the best way to minimise the waste from buildings in Japan is to reduce demolition activity. They consider that prolonging the life span of buildings will have a greater influence on waste from an increasing demolition activity.

To overcome the inhibiting factors Yashiro (1994) highlighted the need for alternative building methods, and suggested:

"1 – in terms of building design, re-utilisable building systems have to be developed and introduced. It is a building system where careful measures for re-utilisation are taken in joint details of building components and building materials and combinations at the initial stage of designing buildings.

2 – In socio-economical systems, a common understanding in terms of required costs for the appropriate demolition of buildings should be established.

3 – The re-utilised materials market should be formed, by the intervention of all actors in process, but regulated by the public authorities, in order to increase the economically feasibility of re-utilisation."

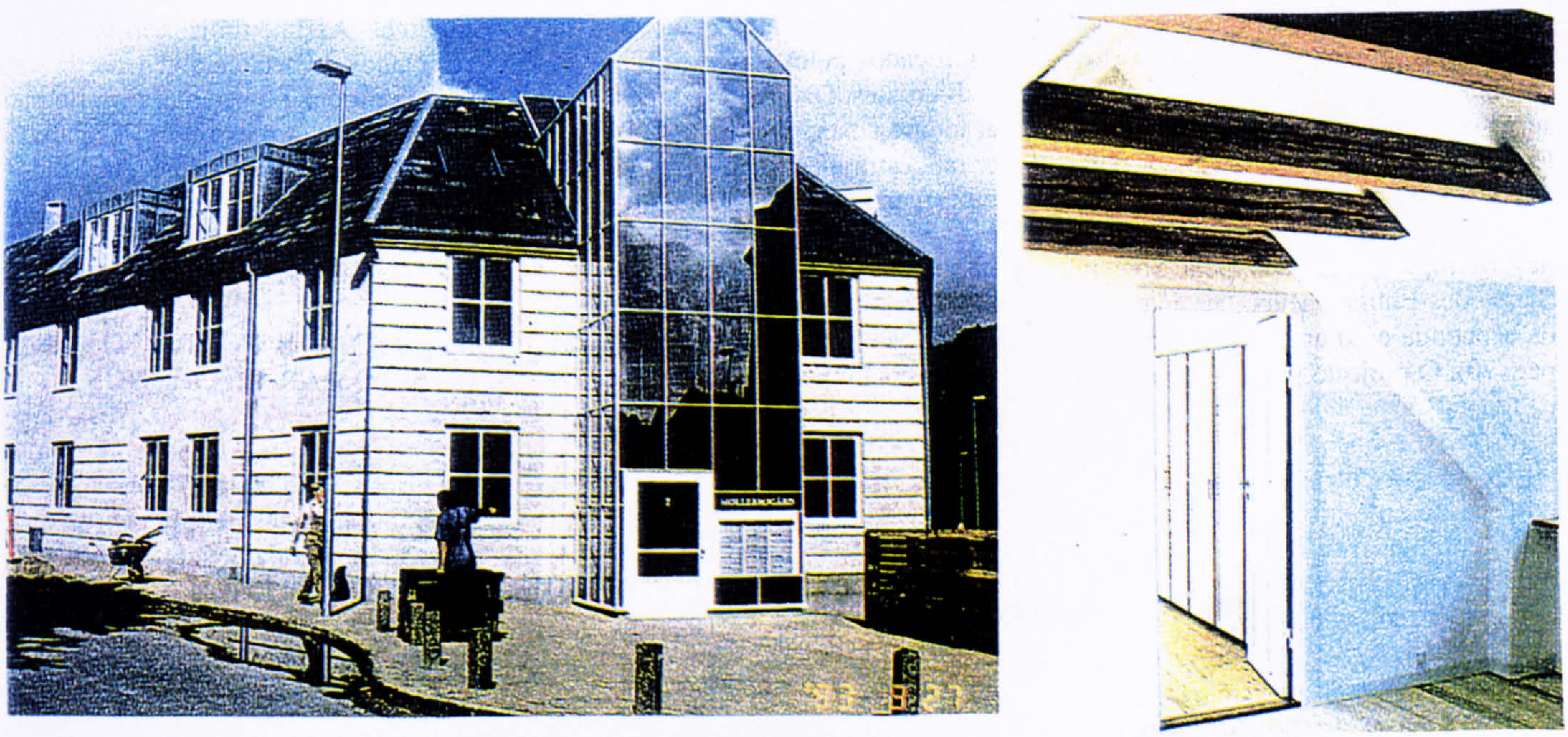
The Odense Recycling House Case Study (Denmark)

The fourth case study presented in this Chapter is probably the most well known project of building recycling materials in Europe. It is a paradigmatic example of the use of recycled materials in new construction. The principal result of this experience is the development of the economic evaluation of projects. The project also provided valuable additional experience in the use of recycled materials in the construction of buildings.

A- Location

The "Recycled House" shown in Plate 7.1 was built in the centre of Odense, a city in Denmark not far from the capital. The building was constructed at the junction of Carlsgade Street and Georgade Street.

Plate 7.1 – Odense "Recycled House" (Denmark)



Source: Silva and Farinha 1994:71.

B- Site and development history

The “Recycled House” was a co-operative housing project subsidised by the taxpayers. Financial responsibility for the project rested with the client, the Odense Urban Renewal Company, and Hoejstrup Co-operative Housing was responsible for the procurement of recycled materials. The development consisted of 14 non-profit flats. The house has two-wings with 3 storeys (2 normal storeys and penthouse flats in the roof structure) plus a basement with a bomb shelter, hobbies rooms and locker areas for the tenants (Olsen 1993:521- 527). There was a fall of approximately 3 metres along the length of the facades, which influenced the design and the layout of the basement. It was completed and occupied in August 1993.

The use of recycled materials in the construction of the flats significantly reduced the consumption of new materials, and led to a reduction in the dumping of waste from neighbouring demolition sites. The components made from recycled materials complied with the Danish Standards. Figure 7.4 shows the components, the recycled materials and the Danish Standards. A significant part of the structure was built from recycled crushed concrete and crushed tiles, used as aggregates in concrete. Reused bricks and roof slates were used in the fabric of the building, and reused timber was used in the structure and joinery.

Figure 7.4 – Odense "Recycling House" Standards for recycled materials

Components	Recycled materials	Standards
Drainage layer	Crushed concrete	Specifications for granular ırve,content of organic material ıd the max. capillary rise
Concrete aggregates	Crushed concrete and bricks	According to an authorized ecommendation
Steel reinforcement	Melted scrap iron	According to ISO 630 Fe 360 e 510
Structural steel	used members	According to ISO 630
Walls	Cleaned bricks	Strength : ds 438
Floors	Used floorboards	Shape : Visual control Strength : DS 413
Internal doors	Repaired used doors	Visual control
Window frames	Cut timber	Visual decomposition control
Roof structure	Cut timber	Visual decomposition control Strength : ds 438
Roof slates	Reused slates	Full shaped after cleaning

DS means Danish Standard.
Visual decomposition control includes control against dry rot and fungus.

Source: Olsen 1993: Fig. 4:525.

C – Reused and recycled materials used

<u>Crushed concrete and tile</u>

The concrete material was largely taken from a demolished road fly-over. The demolition of this structure included several full-scale tests concerning load deflection, demolition and recycling. The rest of the concrete aggregates were taken from an old concrete air-raid shelter situated on site. Crushed tiles were delivered from a municipal recycling plant.

Bricks

Bricks for external and internal walls were selected from two demolition sites in Odense, one of them on the neighbouring plot. The bricks were divided into two classes as follows:

- Class 1. Bricks originally placed in external facades.

- Class 2. Bricks originally placed in other load bearing walls.

Class 1 is expected to have been proven frost-proof and was used in the external walls. Class 2 was used in internal walls. Preliminary tests proved a very high variation in the strength and it was decided to specify a rather low compression strength of 10 MPa. 130.000 cleaned bricks were needed. They were cleaned by hand as no efficient brick cleaning machinery was found. They were sorted, stocked on pallets, wrapped in plastic and stored outside.

Timber

Timber was collected from several demolition sites. The timber used was both long full shaped beams used in the entrance house and shorter simple beams and boards. The old sound wood proved to be heavier and stronger than contemporary building timber. The selected timber was both tested visually and inspected for dry rot and fungus. Timber for structural components was then graded according to strength. Major cuts or holes and large seasoning splits were grounds for rejection.

Roof slates

Roof slates were taken from several demolition sites in Odense. They were cleaned and re-laid. For all components existing standards for new materials were adapted.

During the construction period, practical problems led to alterations, for example the prescribed steel profiles were not available as used materials.

D - Waste stream generated

The project demonstrates that 75 % of the wood, 80 % of the slate and 50 % of the tiles from the old building were reusable. Over 2.000 metres of rafters were planed and processed for reuse and the carpenters on the project believed that the old wood was of superior quality to new timber. 700 sq.m of flooring was made from recycled wood. Forty four original internal doors, were used in the new building, and all windows and cupboards were made from recycled timber. The workers found that reusing old bricks was more difficult than reusing old timber. This was due to the difficulty of cleaning the bricks and sorting them into different grades. It was time consuming and require a great deal space (Warmer Bulletin n° 47 1995).

E - Summary

The main conclusion is the necessity to have an economic evaluation of the project. A question that arises is the need to know the optimal way of using the crushed aggregates in building industry. Is it better to use it in building or road construction? Another conclusion, is that there is a need for more experience in recycling, and to combine the evaluation of the existing experiences of recycling house projects.

Lessons from this case study need to be understood in the context of links to other recycling house case studies in Denmark, for example in Copenhagen and Horsens. The project using recycled crushed concrete for road pavements at the new Copenhagen airport, are of interest as is the guidance from the Danish Building Industry and Danish Environmental Agency. The necessity for all materials to comply with appropriate standards is important. However it is important to note, that most standards are designed to apply to new material and are not suitable for application to recycled materials.

The Hulme Case Study (United Kingdom)

The fifth case study referred to in this Chapter is about a UK experience at Manchester. It highlights some important factors in selective demolition practices. Issues such as building life cycle analysis, embodied energy in materials and products are studied. The concept of ecological footprint is presented in the study of the scrap steel trail.

A - Location

This case study was conducted at Hulme, Manchester, UK, and the site is located at the junction of Royce Road, Claburn Road and Chichester Road in the City of Manchester, in the North West of England (Golton 1996).

B - Site history

Engels referred to Hulme in 1844 (Golton 1996), as " ... one great working-people's district, the more thickly built-up regions chiefly bad and approaching ruin, the less populous of more modern structure, but generally sunk and filth". Waves of demolition and new developments occurred on the site since 1844. The subject of this study was a development that replaced a three-storey terrace housing development in the 1960's.

C - Dismantling and Demolition

The decision to demolish the property before the buildings became physical obsolescence, was taken by the Manchester City Council on the basis of user unacceptability. The property was structurally sound, and for the most part, weather-tight. Social attitudes created a political pressure which forced demolition. Golton (1989) discussed the dynamics and the various determinants forcing demolition. He explained why there were circumstances which drove the demolition of buildings when for many reasons the buildings still had utility.

The demolition works consisted of seven storey, deck access dwellings, a public house and a small number of shops. The demolition contract was put out to tender by the Manchester City Council. The contractor was free to determine the demolition technology and the method of waste disposal. This was not a sound recommendation in the context of the need to maximise reuse and recycling but it was norm at the time.

The required the contractor to be a member of the National Federation of Demolition Contractors. That condition gave a level of guarantee for the quality of the demolition activity. It excluded the "fly-by-night" contractors whose work would have been suspect and would have needed to be closely inspected and supervised. The dismantling began with the company using labour intensive techniques to strip and sweep out the buildings. This action was developed with care to preserve the quality of materials and components in order maximise the price for the sale salvaged materials. The time spent in stripping out reusable items from the buildings reflects under Golton's (1996) point of view a change in attitude within the demolition industry.

D - Waste stream generated

Normally buildings were demolished by the ball and chain technique. This created a pile of debris that was then transported to landfill. This demolition option is a good example of dismantling with selective demolition. In this case study, components from the original strip included: sanitary units, baths, sinks and doors, which were sold to specialist suppliers of second hand building components. Asbestos was located on the site and due its hazardous nature, was removed by specialist contractors, securely contained and landfilled at an authorised site.

Lead, copper and brass components were stripped from the building and sold to scrap metal merchants. Wood removed was burned on site. Steel was separately stripped from the building. The reinforced concrete shell structure was demolished with the chain and ball technique and all the steel removed. It was sold for export to China via Liverpool. British steel makers are reluctant to take construction scrap metal as, they argue, it creates difficulties with quality control. After the concrete and stone was crushed on site it was used to fill old cellars of previous developments discovered during the demolition works. York stone floors abandoned in a previous demolition 30 years ago, were recovered and sold for reuse. Other material classified as waste was disposed of in landfill.

E - Summary

According to Golton (1996) the lessons learned were:

1 – The condition of fabric for building did not determine the decision to demolish. In this study a political decision under social pressure led to the decision to demolish. The buildings were not physical obsolete but social pressures were more significant.

2 – The contract was silent on the need to reuse or recycle the demolition debris where possible. An increase in the tax on landfill disposal as part of an integrated waste management policy could inhibit disposal to landfill and act as an incentive to more sustainable practices. The unpredictability of the second hand building components market is a disincentive developing sound recovery practices.

3 – The wood burning on site, in spite of a licence by the Manchester City Council, is not an appropriate solution.

4 – The recovery of lead, copper and brass is well developed as the metals are valuable and there is an established and stable scrap recycling market.

5 – Steel scrap exported to China for reprocessing is not a good environmental solution in terms of sustainability. There is significant wasted resource in the lengthy transport.

6 – Concrete crushing is a solution for recycling and further use in second class concrete or road bases. However it is a solution that is deficient in terms of embodied energy. Concrete has a high rate of embodied energy and the act of crushing increases the high embodied energy. There needs to be a reduction in the demolition activity or reuse of components instead of recycling. This accords with the Japanese teams conclusions (Yashiro 1994).

The Parque Expo'98 Construction and Demolition Case Study (Portugal)

The last case study reported is the Parque Expo'98 exposition in Portugal. This experience constituted a milestone in the Portuguese approach to these construction and demolition issues. The description of the work undertaken and the limited economic analysis demonstrated how far Portugal is behind other countries in dealing with the construction waste stream and in the movement to sustainable construction. It demonstrates the necessity to develop a consistent strategy for the construction and demolition waste stream.

A - Location

The area of 330 ha including 5 km of riverside frontage is located at the Western part of the city of Lisbon. It is adjacent to the new Vasco da Gama bridge over the Tagus river (rio Tejo). It was land principally occupied by oil companies.

B - Site history

The site was wonderful landscape until the beginning the last century just before the industrial revolution. It was a rural area not far from the city where agriculture and cattle had their natural space. It was an area where wealthy farmers lived and palaces were built to take advantage of the country and the riverside views. This environment changed in the second part of the last century with the industrial growth occupying the agricultural area. By the 1990's the area was occupied by obsolete industrial facilities dominated by the Petrogal refinery, Lisbon's industrial abattoir, the general armaments depot, the Beirolas waste dump and the Solid Waste Treatment Plant, in addition to various harbour facilities. It was in an advanced state of decay.

The Lisbon World Exposition of 1998 (EXPO'98 1998) project provided a vehicle to address the problem. It was an intervention strategy to create a high quality urban framework providing unhindered enjoyment of green spaces and free use of the riverfront. It involved the dismantling and demolition of the existing structures includes obsolete industrial facilities. It addressed the problems of the construction and demolition waste stream and of soil remediation (Castelão 1998). The strategy included an option to use reused and recycled materials from the deconstruction process. This implied the need to develop an integrated construction and demolition waste management plan. A model of environmental management was defined, implemented and monitored during the event and continues into the future (EXPO'98 1996). 60 ha of land on the riverside were transformed, with thematic pavilions, public areas and squares and will remain a leisure space for the future.

Plate 7.2 – EXPO'98 area. Before (A) and after (B) urban intervention

(A) (B)

Source: EXPO'98 1998.

C - Dismantling and Demolition

A technical and economic study was made prior to the commencement of the demolition and reuse and recycling of the materials in the reconstruction. The studies demonstrated that economic considerations linked to transportation cost, accessibility, difficulties in landfill space and high tender prices indicated reuse and recycling of materials wherever possible. Environmental considerations were noted but economic considerations drove the process. The chosen contractor worked under a joint agreement with a UK contractor and had a semi-mobile hardcore recycling plant on site. The deconstruction process began with a general dismantling phase (Procesl 1997) where components such as roof slates, lead, copper brass were removed and sold to reprocessing and second hand suppliers. These suppliers had their operations close to the EXPO'98 area. Plate 7.3 gives a view of the recycling plant (EXPO'98 1998).

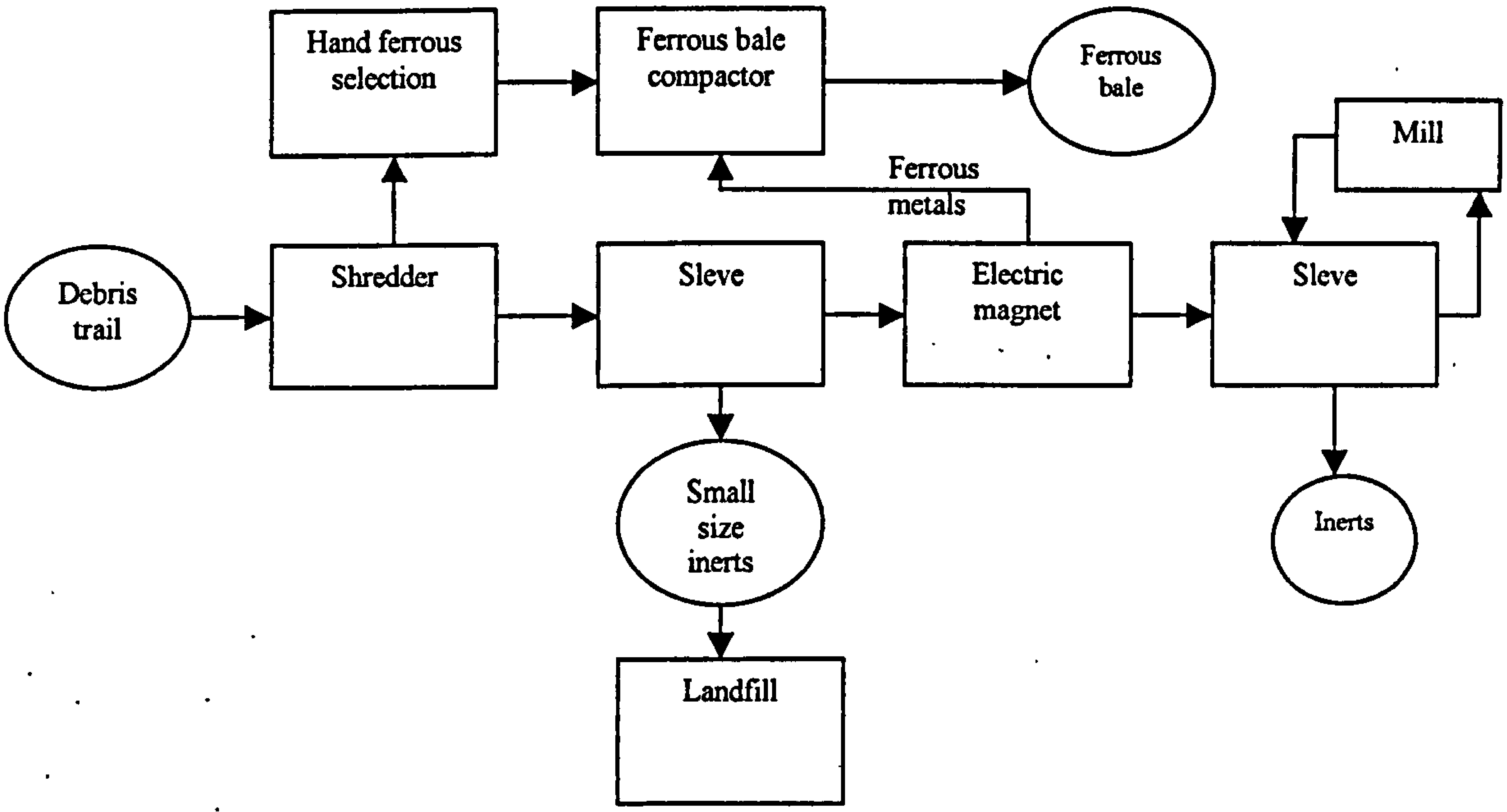
Plate 7.3 – Recycling Plant in Parque EXPO'98

Source: Castelão 1998.

Asbestos sheets were put in securely closed bags and disposed into landfill. The stones from the old roads and stone masonry were reused on site. The demolition phase began with the demolition of buildings with hydraulic caterpillar cranes with pincers. Ball and chain systems were also used.

All the inert material to be recycled was placed upstream of the recycling plant. It then entered the crushing and sorting process at Area A. Figure 7.5 presents the recycling plant flow chart.

Figure 7.5 – EXPO'98 recycling plant flow chart



Source: Procesl 1997.

Area A had two vertical primary jaw and shredder machines with magnets, metal scissors and rolling belts. It carried out the first concrete crushing and separation working at a speed of 80 tonnes per hour per unit. The second area, Area B, had a horizontal primary jaw machine with rolling belts and carried out a second crushing operation and metal separation. Area C had the last fragmentation facility with sieves and rubber belts. It had finishing facilities to feed separate piles of material differentiated by quality and granularity (Águas & Resíduos nº 8 1998).

D - Waste stream generated

The recycling plant worked on two 10-hour shifts of 15 men (EXPO'98 1996). The concrete recycling involved 812,000 tonnes of crushed materials and 190,000 tonnes of brick and stone masonry. All the materials were used on site to fill low topography landscaping, and as a base for pedestrian walking areas, car parks and other works which were not covered by precise technical codes. The 60.000 tonnes of bituminous pavement was also recycled and reused on site.

E - Summary

The environmental budget for the development of works were $m 2.275.000. The demolition and remediation activities accounted for 7% of the total budget.

The recycling plant and complementary facilities were the first to be used in Portugal. Castelão (1998) organising visits to the recycling area and two workshops were developed under INR supervision to disseminate the information to a wider audience. Those activities proved to be insufficient to link the experience to the national context. It did not generate the expected discussions and further work to develop a strategy to prioritise this waste stream. It is apparent that the data collected in the fieldwork has already been mislaid and cannot be retrieved.

The current challenge is to build on the experience and knowledge to develop a national construction and demolition strategy.

SECTION 2: LESSONS TO BE FOLLOWED FROM THE CASE STUDIES REPORTED

One factor that is significant is the economic factor. It is always present and carries more weight than the environmental issues. Levies on wastes going to landfill and appropriate taxes on virgin aggregate are essential to align the economic argument alongside the environmental argument in the development of a sound construction and demolition waste strategy. Technical and scientific procedures must be enhanced to move towards sustainable practices. Legislation is a major driver influencing the decision to manage waste in particular way. Designing for the protection of the environment maximising the reuse and recycling of materials is also fundamental. The absence of reliable data and criteria to develop further comparative case studies is also a handicap. However the results from these case studies will contribute to defining a dynamic model. They highlight the issues which are fundamental to achieving sustainable construction.

Referring to the results from the six case studies reported and to some presented by the Warmer Bulletin n° 61 (1998) it is clear that a strategy must be developed which involves all the actors and is based on the following:

- Architects, designers and engineers should develop and adopt sustainable concepts. They should promote high quality workmanship for durability. Poor quality products become waste sooner. There is a need to reduce the need for temporary work during construction. There is a need for the design to be more efficient using less material. There is a need to incorporate standard sizes in plans, reducing the need for off cuts and wastage. Less originality can mean lower environmental costs. There is a need to design for, and specify, the use of recovered material.

- Construction companies should make clearly marked storage available for new and waste materials, much wastage occurs as a result of damage to new materials improperly stored. There is a need to avoid mixing materials. There is a need to encourage workers to keep materials separate for recycling. Contracts with sub-contractors need to be written to promote reuse and recycling of materials.

- Local Authorities should require sites to be as self-sufficient as possible, encouraging reuse and recycling on site. There is a need to include in tender specifications a requirement for waste and recycling plans and to give contractors preferential treatment if they adopt environmentally preferable behaviour. Provide a list of sources of recycled materials available in the region.

- Governments and Trade Associations should conduct research into a range of different recycled material specification. There is a need to establish performance tests for quality control and fitness for purpose of reused and recycled materials to overcome poor quality image and anxiety about variable performance.

In summary, these results constitute a quantitative but also a qualitative contribution to defining the model. Each case study has demonstrated a particular set of issues. Together they have demonstrated that there are many issues still to be addressed with respect to the construction and demolition waste stream. This thesis, and the construction and demolition dynamic model at the core of the research aims, making a significant contribution towards a deeper understanding of the deconstruction process with respect to maximising the reuse of resources.

CHAPTER 8:

THE PORTUGUESE EXPERIENCE AND THE LISBON CONSTRUCTION AND DEMOLITION WASTE CASE STUDIES

"Small is beautiful"

(Schumacher 1911-1977)

INTRODUCTION

This Chapter concerns the Portuguese experience in the construction and demolition waste stream and the recent trends in waste management. It also focuses on the characteristics, data collection and the civil works of the Lisbon area multiple case studies. Section 1 is focussed on waste management in Portugal it concerns the legislation and the state of the art in the construction and demolition waste stream.

Section 2 concerns the characteristics of Lisbon in the context of the research. Section 3 concerns the types of civil works in Lisbon area. Section 4 is about the Lisbon area multiple case studies. It gives a general description, discusses criteria for the selection and other significant issues concerning the case studies. The collection, treatment and interpretation of the data in the Lisbon case studies are also discussed. The difficulties in developing the case studies with specific reference to the significance of the actors' participation, attitudes and behaviour in the process are also discussed.

The first Section puts the research into context. It is important in order to understand the development of the case studies and to give insight into their strengthens and weaknesses. The urban characteristics of Lisbon in terms of the evolution of building types and the areas characterised by similar types of construction are set down and the importance of these characteristics are discussed. The characterisation of the construction industry in Lisbon area is also discussed.

SECTION 1: WASTE MANAGEMENT IN PORTUGAL

In 1996 Portugal had a population of 9,9 million (INE 1998), Figure 8.1. The population density was 108 persons per sq. km. with the majority of the people living in the coastal regions, leaving the interior relatively sparsely populated. Figure 8.1 gives some basic facts about Portugal.

Figure 8.1 – Portugal basic facts

Area	91,985 sq km
Population	9.9 million
Working population	4.7 million
Population density per sq km	108
Capital	Lisbon
Main religion	Roman Catholic
Language	Portuguese
Currency	Escudo
GDP growth rate	1.9 (1995)
Import % GDP	29.9% 1995)
Export % GDP	19.6 % (1995)
Inflation rate	3.1% (aggregate 1996)
Unemployment rate	7.3 % (1996)
UK Export to Portugal	1,654 £m (1996)
UK Imports from Portugal	1,640 £m (1996)
Exchange rate	£1 = 300 escudos (Dec 1997)

Source: INE 1998.

Up until 1980, waste management was seen as part of the general area of sanitary engineering. It was given little specific attention and funding beyond collection and disposal, which was the responsibility of municipalities. From 1980 to the present date waste management took on a progressive important profile. It was stimulated by Portugal's anticipated and then actual membership of the European Union. Entry to the Union would oblige Portugal to have national legislation corresponding to that of the Member States. Portugal joined the European Union in 1986.

In 1987 "The Basic Environmental Law" was enacted by the Decree Law nº 11/87 of 7th of April, 1987. It highlighted a general principle that "Environmental policy has the objective of optimising and guaranteeing the continuous qualitative and quantitative use of natural resources as a basis of sustainable development". It forms the principal framework for legislation on the environment.

Waste management in Portugal has received significant support from the European Union in order to achieve European Union levels of environmental quality. This improvement was accomplished by the efforts of Government and Public Authorities. The private sector was also involved.

The Ministry of the Environment and Natural Resources (MARN) had been established in 1990 becoming responsible for environmental matters. They had previously been the responsibility of the Ministry for Territorial Planning and Administration (MPAT). Three bodies established in 1987 by the Basic Environmental Law and previously part of MPAT became part of MARN. They were the Nature Conservation Institute (ICN), the National Environmental Institute (INAMB), and the National Meteorological and Geophysical Institute (INMG). In addition to this, a Consultative Committee on the Environment was also established to advise MARN. They were restructured in MARN to become the Institute of Environmental Promotion (IPAMB), the Consumer Institute (IC), the Meteorological Institute (IM), the Nature Conservation Institute (ICN) and the Water Institute (INAG) and the General Directorate of the Environment (DGA). The five Regional Directorates, legally defined in May 1993, remained the same. The structure remained unchanged until August 1996. In 1996 the Institute of Waste (INR) was created by Decree Law n° 142/96 from the Solid Waste and Recycling Directorate as part of the General Directorate of the Environment (DGA) and MARN was renamed the Ministry of the Environment (MA).

The Ministry of the Environment is the central body that acts through the Regional Directorates of the Environment. The Madeira and Azores Islands have regional autonomy with there own Regional Directorate for the Environment. The Inspectorate General for the Environment (IGA) was recently redefined and given more autonomy at the same a Water and Waste Industries Regulatory Body (IRAR) was created. The Inspectorate General for the Environment investigates and develops appropriate inspection and audit systems on all environmental issues. It also set the penalties where necessary. The objective of the IRAR is the protection of consumers by the control of costs and quality of service of the entities responsible for the management of the wastes and water supply. On 8th September 1997, the Institute of Waste was recreated by Decree Law nº 236/97 at the same level of the other Institutes and the General Directorate of the Environment (DGA).

The Ministry of the Environment is the government body responsible for Portugal's policy on waste. The Waste Institute (INR) has the responsibility for carrying out the national policy on waste issues. It originated the National Solid Waste Strategy and the Sector Plans for Urban (Municipal), Agricultural, Industrial and Clinical Wastes. It is responsible for promoting research in the waste sector, the management of packaging waste and prioritising waste streams. It is the licensing authority for waste management operations and technical systems.

Portugal had lacked a proper urban and industrial waste management for many years and by 1995 the situation had declined reaching totally unacceptable levels. In that year Portugal produced around 3500×10^3 tonnes of urban (municipal) solid waste. Whilst around 95% of the population was served by waste collection systems approximately 70 % of the total waste ended up in more than 300 unregulated tips, or uncontrolled dumps, scattered throughout the country (EC 1997b). This caused serious damage to the environment and public health and was of great concern to neighbouring populations. It was also of concern to the Public Authorities and the technical and scientific community. The situation required immediate remedial action. After the 1995 elections the new government started to address the issue and define a sound management strategy.

Two important documents were published with significant implications for waste management policy. They were the National Environmental Policy Plan (MARN 1995a) published directly by the Ministry of the Environment in March 1995, and the Project for the National Plan for Waste (MA/DGA 1995), published by the General Directorate of the Environment in July 1995.

The Project for the National Plan for Waste (MA/DGA 1995) analysed the waste situation in the country. It considered the future evolution, objectives and actions to develop and the sources of investment and funding. It considered that action plans needed to be developed for urban (municipal) waste, for industrial waste and for hospital (clinical) wastes. It also included consideration of the entities that needed to be involved or created to address the problem. Trans-frontier movements of wastes and wastewater treatment sludge were also considered. No mention was made of the construction and demolition waste stream as well as other priority waste streams set down within European Union guidelines.

The Project for the National Plan for Wastes (MA/DGA 1995), provides information on the Cohesion Fund, the Operational Programme of the Environment (POA), the Strategic Programme to Stimulate and Modernise Portuguese Industry (PEDIP) and the National European Fund for Regional Development (FEDER) as sources of investment and funding. The National Plan for Wastes set two specific challenges for municipal solid waste. Starting from 1995 it was necessary:

1 – to eradicate all uncontrolled dumps and tips.

2 - for all the Councils (municipalities) to be in possession an adequate system of management for their wastes (Wastes Management Plans).

To meet these challenges four principal objectives were defined:

1 – Prevention. To reduce waste by the concerted efforts of consumers and producers.

2 – Treatment. The fraction of wastes disposed of directly to sanitary landfill should not exceed 35 % and that disposed of by incineration should not exceed 30 % by 2005.

3 – Recovery. Energy recovery targets of 20 % and 15% were set the years 2000 and 2005 respectively for recycling and composting.

4 – Eradication. Uncontrolled dumps or tips, to be banned, closed, sealed and

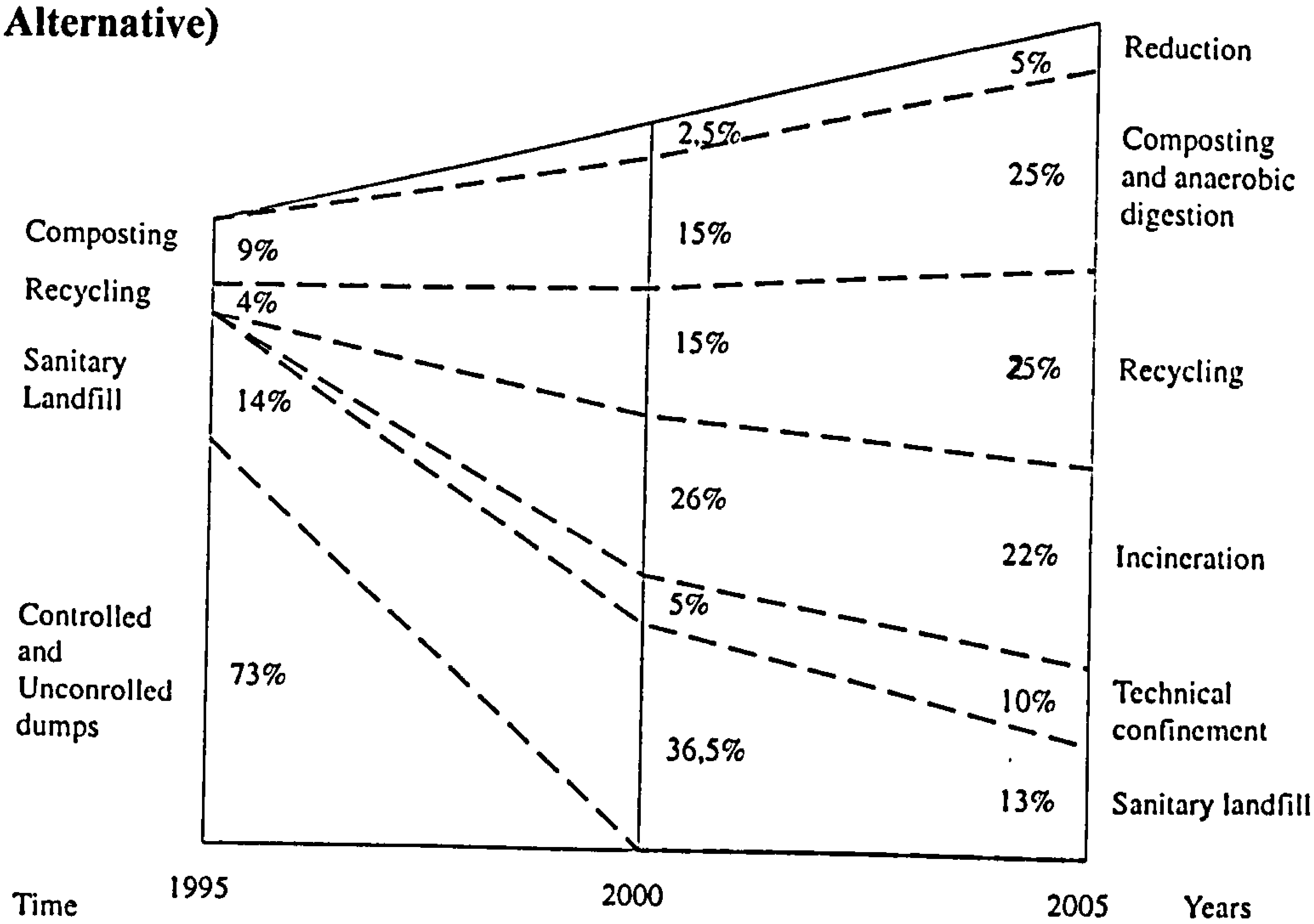
monitored, and substituted by other technical systems, mainly landfills by 2000.

The 1995 baseline was that the rate of municipal solid waste collected was about 98 %, of which 12 % was composted, and 34 % went to landfills. The rest 54 %, of the total of municipal solid waste was disposed of in uncontrolled dumps (MA/DGA 1995).

The figures from the National Strategy (MA/INR 1997) for 1995 were worse. The rate of composting was put at 9% not 12 % and the total waste finally disposed of in sanitary landfills was put at only 14 %. The municipal solid waste disposed of in uncontrolled sites was put at 73 % dumped not 54 %.

The Strategic Plan on Urban Solid Wastes (MA/INR 1997) was developed from 1996 by a working group under the supervision of the Ministry of the Environment and outlined the main national objectives and targets within the European Union strategy. The government approved it in 1997. Figure 8.2 shows the goals and the quantified targets based on the year 1995 with short-term targets for the year 2000 and medium term targets for the year 2005.

Figure 8.2 – Goals and Quantified Targets on Municipal Solid Waste Strategy (Selective Alternative)



Source: MA/INR 1997:64.

The three main priorities of the Municipal Strategy Waste Plan (MA/INR 1997) which drew on the National Plan for Wastes are:

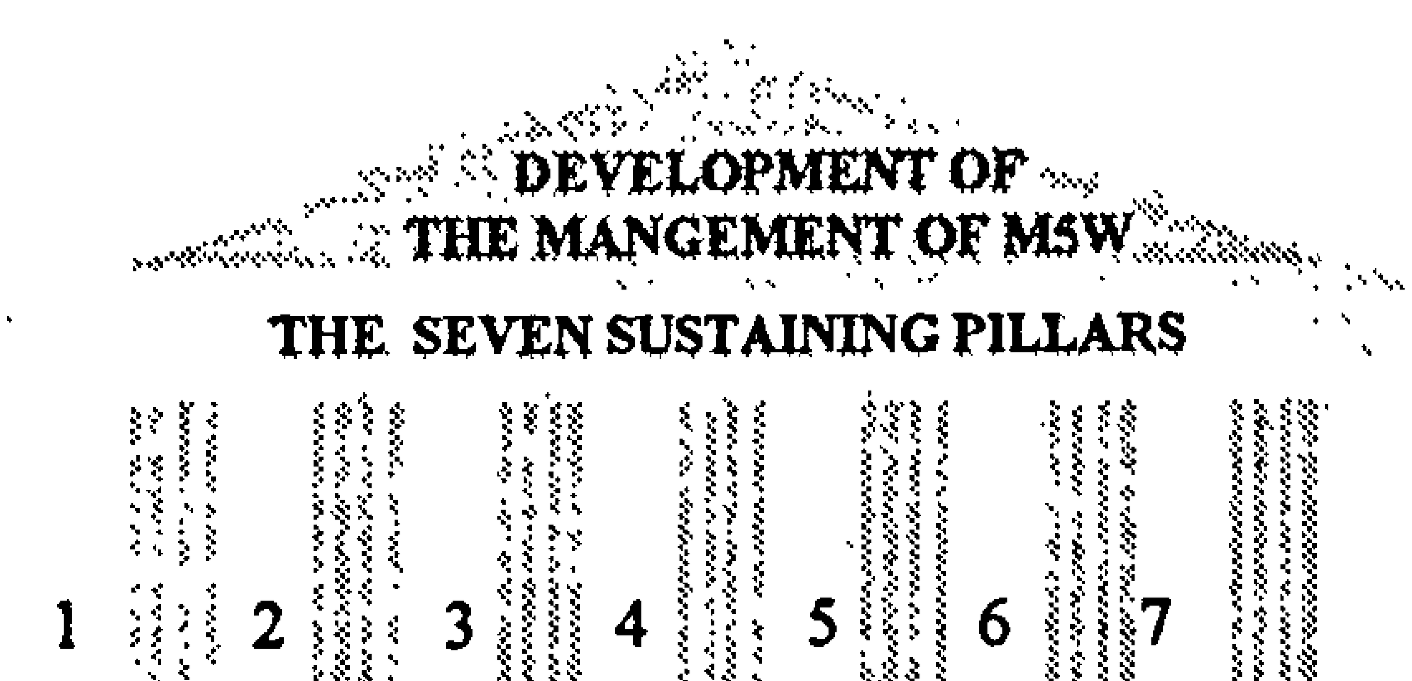
1 - To close and seal existing uncontrolled dumps and ensure that the areas are rehabilitated and landscaped.

2 - To construct a new infrastructure for the treatment and management of waste and ensure that the new companies are properly managed.

3 - To start up selective collection systems.

Seven pillars support the development of the new integrated municipal solid waste management programme. Five issues constitute the basis of this strategy, which could be compared to a building structure, as shown in Figure 8.3.

Figure 8.3 – Structure of a Sustainable and Integrated Municipal Solid Waste Management

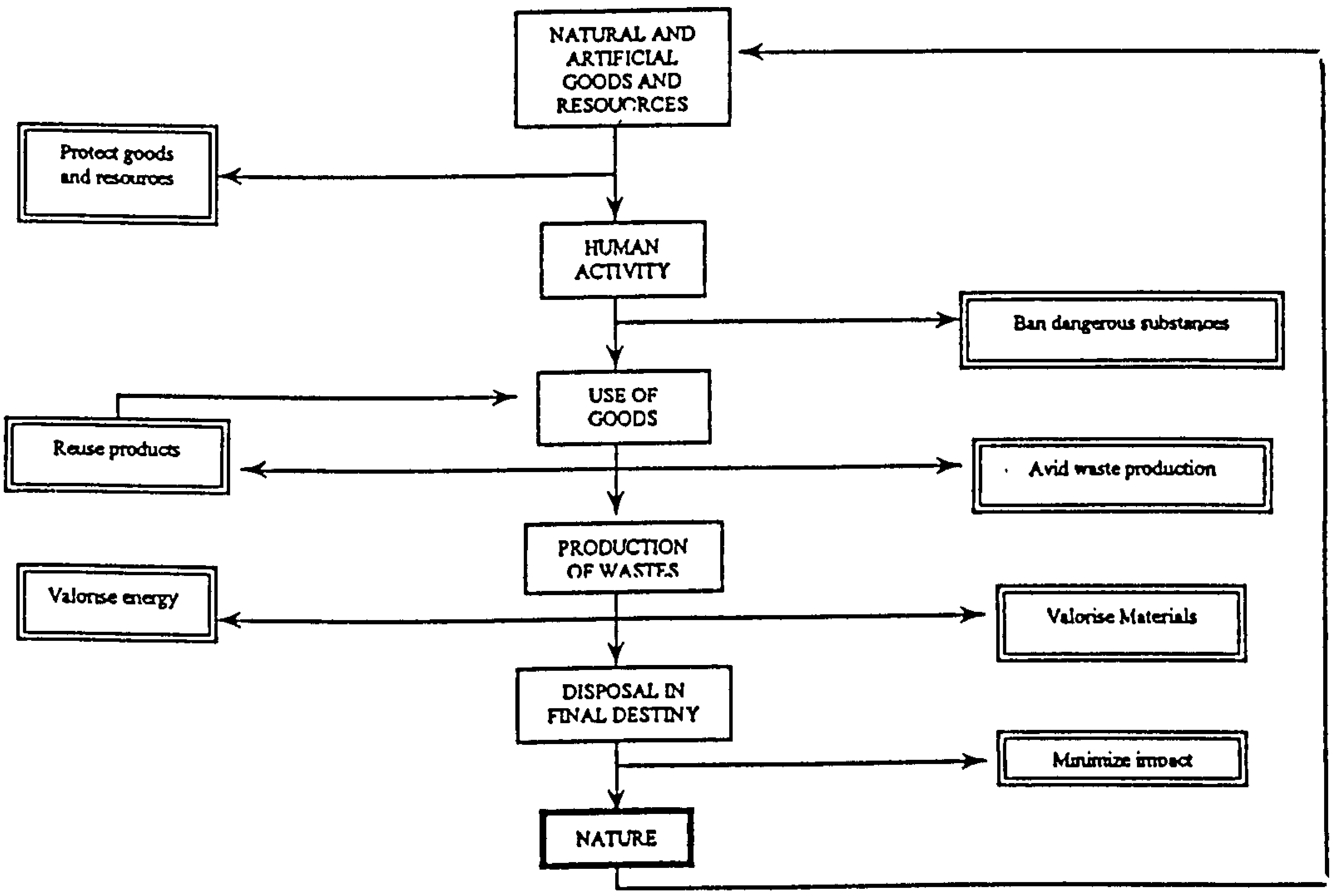


Pilar 1 – Management and managing bodies (entities)
Pilar 2 – Cost of service, user price
Pilar 3 – Prevention, reduction, reuse
Pilar 4 – Recycling
Pilar 5 – Composting
Pilar 6 – Recovery
Pilar 7 – Confinement

Source: MA/INR 1997:3.

The main pillars of this strategy are; management of the new entities and managing bodies; cost of service/user price; prevention, reduction, reuse, recycling; biological treatment; recovery and confinement. It is based on an anthropocentric approach to ecological systems and the protection of nature. This is the base of the mesosystem concept displayed in Figure 8.4. Faria (1993) explained the mesosystem concept as it applies to human health as a concept supported by the mesologic model. The mesologic model considers man at the fulcrum of all concerns rather than one concern among many as in the ecological models. The model does, however, concern itself with the biophysical and psychosocial issues and interactions.

Figure 8.4- The Mesosystem and Wastes



Source: MA/INR 1997:6.

The Municipal Solid Waste Strategy Plan outlines the processes of national waste management. The Plan accommodates the general fiscal, geographic, social-economic, institutional and financial constraints, including the constraints derived from the conditions already assumed.

The plan (MA/INR 1997) describes the environmental and technical characteristics of integrated wastes management and highlights the intrinsic and operational dysfunction. The Strategy includes an assessment of the current state of waste management and makes forecasts for the years 2000 and 2005 (MA/INR 1997) (see Table 8.1).

Table 8.1 – Distribution among the diverse elements of management, of the quantities of Municipal Solid Waste produced in 1995. Future short term (2000), medium term (2005) options

Elements of management	Present situation (1995)	Prevision of future situation				
		Year 2000			Year 2005	
	Quant.	%	Quant.	%	Quant.	%
Reduction	0	0	100	2.5	225	5
Composing	299	9	580	15	1123	25
Recycling	133	4	580	15	1123	25
Incineration	0	0	1000	26	1000	22
ECTU	0	0	194	5	450	10
Landfill	471	14	1416	36.5	569	13
Dump	2437	73	0	0	0	0
Totals Valoris.	432	13	2260	58,5	3471	77
Totals Confin.	2908	87	1610	41,5	1019	23
OVERALL TOTAL	3340		3870		4490	

Source: Shinn 1997, Table 2:20.

The Strategic Plan is the core of the national municipal solid waste policy and defines the overall goals and targets for years 2000 and 2005. These years are defined as short and medium term under the European Union guidelines. In the reference year, 1995, there were 351 (the first survey revealed only 302) uncontrolled waste dumps and tips, 9 landfill with some control, 13 sanitary landfill and 5 composting plants. These are discussed by Shrinn (1997) and shown in Table 8.1. The Portuguese Municipal Solid Waste Strategy highlights the following principles:

1 - Prevention of production - reduction

This first priority, prevention, is expressed in three levels:

- Primary prevention – programmes and actions that tend to avoid, at source, the production of wastes and/or their danger to man and the environment.

- Secondary prevention – includes actions destined to avoid the potential problems resulting from the operation of collection to final disposal of the municipal solid waste management technosystems.

- Tertiary prevention – aims at avoiding confinement of valorise municipal solid waste or wastes dangerous to man and the environment, seeking to make the dangerous wastes inert before disposal.

However, few practical recommendations are made to achieve the reduction target of 2.5 % of the total in the year 2000. General guidelines are made concerning education for reduction of waste and consensus with economic agents. This consists of establishing fiscal benefits for the most successful company waste reduction programmes and aid to the local authorities (MA/INR 1997).

2 – Recycling - Packaging

Recycling has been divided into two basic areas. One is recycling the organic matter with particular emphasis on composting but also considering the development of new anaerobic digestion plants. The other is related to material recycling such as paper and cardboard, plastics, metals, glass and other packaging.

The biological treatments, composting, anaerobic digestion and bio-methanisation were 9 % of the total in 1995. They were forecast to rise to 15 % by the year 2000 and 25 % by the year 2005. Organic recycling, or biological treatment, is predicted to grow to 64 % of the total in Lisbon and its 3 closest neighbouring local authorities. In the city of Porto and its closest neighbouring local authorities it is predicted to grow to 26 % of the total with the other 10% from the rest of the country (MA/INR 1997). Organic recycling is seen as highly desirable in a country that was classified with Spain as having the worst soil resources in Southern Europe. The lack of organic matter, soil quality, erosion and desertification are serious concerns.

The material recycling area should be further subdivided as follows:

A – Paper and cardboard. This makes up approximately 22.3 % of the total national urban solid waste 70 % of which is non-packaging. Assuming a 40 % retrieval rate of this waste stream there is a potential for valorising 6.2 % of the total. Plastic, metals, glass are also three waste streams which could be similarly valorised (MA/INR 1997).

B – Packaging is approximately 25 % of the total volume of municipal solid waste. 25 % of this or 6.3 % of the total is the target to be recycled in this waste stream (MA/INR 1997).

In total 12.5 % of all wastes, or possibly 15 % with the plastic, metal and glass could be recycled but no areas in the country has been selected or predicted to make a particular contribution to these targets (MA/INR 1997).

3 - Incineration

Two incinerators with energy recovery have just been constructed, one in the Lisbon area and the other in the Porto area. This is equivalent to processing 26 % of the total municipal solid waste production by the year 2000 considering a 3 % increment per year from 1995 to 2000. The incineration capacity is to be maintained at this level. Whilst the overall amount of urban solid waste will increases to 2000 waste prevention and minimisation programmes will reduce the figures from 2000 to 2005. It is forecast that incineration will play a diminishing role, relative to the other treatment methods, over the 20 year life span of the incineration plants. This represents the minimum possible quantities of waste that can be processed by incineration (MA/INR 1997).

4 -Confinement

Technical confinement is a solution of storage under appropriate environmental and safety conditions awaiting further cleaner technology for treatment and eventual disposal.

The target to be disposed by sanitary landfill is 36.5 % and 5 % by technical confinement making a total of 41.5 % by weight of the total municipal solid waste stream by the year 2000 (MA/INR 1997). The focus of this strategy is the total eradication of uncontrolled dumps and tips by 2000. The targets for 2005 are 13 % for sanitary landfill and 10 % for technical confinement (MA/INR 1997).

The Municipal Solid Waste Strategy sets out guidelines to achieve the goals. They are as follows:

1 – Regional Waste Management Entities.

Recent legislation allowed municipalities to jointly establish cost effective regional level associations to tackle waste problems. A total of 32 associations covering the whole of mainland Portugal are now in place and operational. There are two models, the multi-municipal system with EGF involvement and the other base on an association of municipalities. The multi-municipal system is type A in Figure 8.5 and there are 13 of them. EGF was set up by the Portuguese government to assist associations of municipalities with expertise and funding in establishing and managing integrated waste systems. EGF is a public company owned by the State Shareholder Institute (IPE). EGF is the major shareholder (51 %) with the balance held by the municipalities. This is due to their strategic importance and the need for substantial investment, as they cover the most populated areas of the country, serving 67 % of the total population. The legislation enables private stakeholders to invest in the companies but does not make the characteristics of the capital participation clear. That may be why there is little interest from the private sector in this option. One multi-municipal company, Centre Municipal Solid Waste Company (ERSUC) with headquarters at Coimbra, has a small private participation. The multi-municipal companies operate waste systems under concession.

The association of municipalities model, type B in figure 8.5, is where the municipalities share the capital among themselves without EGF participation (EGF 1996).

Figure 8.5 – MSW Investments by companies (Type A and B) (10 Millions Esc equal to 50.000 Euros)

TYPE	COMPANY	EXPENDITURE	
A	Muiti-municipal systems		
	VALORMINHO	4.5	.
	RESULIMA	10.5	
	RESICÁVADO	4	
	BRAVAL	6	
	SULDOURO	16.5	(1)
	VALORSUL	159	
	ALGAR	47	(1)
	ERSUC	· 30.5	(1)
	AMARSUL	58	(1),(2)
B	Associations of municipalities		
	AMTRES	15.5	(3)
	LIPOR AMAVE	119	
	TOTAL (Millions of Euros)	481	

2 – Technical requirements.

There is a requirement to establish regulatory structures. Clear specifications of appropriate plans of implementation and of the relations between the different agents involved in implementation are fundamental. It is also necessary to establish training programmes for a body of environmental inspectors.

3 – Budgets

Estimates of costs and details on the areas of investment are set down to the year 2000. They include the percentages deriving from national and European Union sources. The global investment is distributed as follows (MA/INR 1997):

. 39.4 % to be spent on new incineration plant for energy recovery.

. 33 % to be spent on new sanitary landfills.

. 14 % to be spent on recycling.

. 12 % to be spent on eradication of uncontrolled dumps and tips.

. 1.6 % to be spent on new biological treatment plants (composting and anaerobic digestion).

The investment in each region includes the following actions:

. Implementation of selective collection schemes.

. Construction of Sorting Plants and solid waste separation centres.

. Construction of Transfer Stations.

. Sealing existing uncontrolled waste dumps and tips.

. Construction of sanitary landfill sites and complementary treatment units, such as the two incinerator plants at Lisbon and Porto, and biological, composting and anaerobic digestion treatment plants.

Between 1997 and 1999, 51 new sanitary landfill sites were built most of them accompanied by an upstream separation centre and sorting plants. The breakdown of the total investment between 1997 and 1999 split by regions is shown in Figure 8.6 and represents the investment by both types of companies.

Figure 8.6 – Total Portugal MSW investment facilities by regions, between 1997 to 1999 (Euros)

Region	New infra-structures	Recycling	Sealing off wate tips
North	171	33.5	18.5
Centre	55.5	1805	15
Lisbon and Tagus Valley	229	44	6,5
Alentejo	21	7	15,5
Algarve	33	6.5	7.5
TOTAL	509.5	109.5	63

The investment Plans includes the multi-municipal systems and the associations of municipalities in Lisbon and Porto. The investment in Lisbon and Porto represents 70 % of the 682 milions of Euros total allocated. 85 % of that funding was from the Cohesion Funds and the remainder from the Government and from the municipalities. The financial support for the remaining systems came from other European Union funds and from Public Administration. During 1997, most contracts placed were for the construction of landfill sites, purchase of ancillary equipment and sealing existing uncontrolled waste dumps. Waste sorting and recycling facilities were under

construction in 1998 and a total of 7500 sorting points and 200 sorting centres will be built. In 1999, additional biological treatment facilities were constructed.

4 – Recuperation of investment

The responsibility for the recuperation of investment by municipal taxes has been allocated. There are also measures to create incentives for selective collection and separation. It describes different collection structures and presents the conditioning factors.

5 – Treatment of waste streams

The relative importance of the responsibilities and action for the treatment of packaging, batteries, glass, paper and cardboard, plastic and metals in the waste streams are raised. The end of life of vehicles, electric and electronic materials, construction and demolition waste has received particular attention. Also actions on specific wastes such as used oils, used tyres, sewage sludge and small quantities of hazardous wastes are addressed.

The Green Point Society was created and officially initiated to manage the packaging waste stream (SPV 1998). Contracts were entered into with the various agents responsible for producing and importing packaging.

6 – Review and evaluation

There was provision for the periodic review, evaluation and modification of Municipal Solid Wastes Strategy.

Legislation Analysis in the Construction and Demolition Waste Stream Context

Portugal has been recognised by the way it includes European Union Directives and Regulations into national law. This includes the waste management area where there is sufficient legislation, but that does not guarantee observance by the community or industrialists. The European Strategy for Solid Waste Management (EC 1996c) set down the European Union position and Portugal must complete the process with specific legislation concerning the priority waste streams. The priority waste streams selected by the European Union are packaging, oils, electric and electronic materials, end of life of vehicles, piles and batteries, tires and construction and demolition waste (EC 1996d). In 1995 Morgan and Argus (1995) addressed the construction and demolition waste stream and countries were advised to develop national plans and actions. At the end of 1997 the Directorate General XI of the European Union returned to focus on the construction and demolition waste stream. The study reported that there were no strategies, plans or specific legislation for construction and demolition wastes. The general legislation in Portugal is not appropriate but has some areas of application to this waste stream. Morgan and Argus (1995) highlighted that there were no construction and demolition waste studies in Portugal.

The State of the Art of the Construction and Demolition Waste Stream in Portugal and Lisbon Area Study

The state of the art of the construction and demolition waste stream in Portugal is in the preliminary stages. This research deals with the first significant efforts to develop work on this waste stream. The author is the Vice President of the Institute of

Waste in the Ministry of Environment and has played a consultative role in many of the projects. He played also a direct role in the multi case studies and in the workshops to involve the actors in the process of change, as well as to disseminate and discuss the results of the projects.

The first Portuguese paper relating the sustainable construction and the construction and demolition waste stream was published in 1994 (Silva and Farinha 1994). Two workshops were held at the Institute of Wastes in 1996, on the management of construction and demolition waste stream. In 1997 a seminar was held at the Ministry of Equipment and Territorial Administration on sustainable construction and the construction and demolition waste stream. A project was undertaken for the Lisbon City Council to study the feasibility of a recycling plant in Lisbon area (Procesl 1997). A protocol was agreed between the Lisbon City Council, the Institute of Wastes and the Institute of Applied Sciences and Technologies, from the Lisbon Sciences Faculty, on the construction and demolition characterisation and quantification in Lisbon area (Appendix D). The same partners are developing another protocol concerning the Carnide civil parish of Lisbon. The objective of the protocol will be to better characterise the construction and demolition waste stream improving on the quality of data from first phase.

In 1997, for the first time, there was a short reference to the construction and demolition waste stream in an official document (MA/INR 1997). The reference was: -

> "- To study the valorisation possibilities of the wastes from demolition, construction and building excavation and from road construction, together with the national industry and contractors selected by tender.
>
> - To introduce special licences and authorisations to demolition contractors who will be required to organise dismantling and site waste sorting or operate recycling plants. To provide links between the legal authorities which provide licences for construction and demolition, for example the Local Authorities and Central Administration of public companies such as the Roads Autonomous Board, and BRISA Portugal Motorway AS.

- To accomplish the management of raw material extraction for the building industry and civil engineering works. To create statistical data by monitoring raw material extraction and waste reutilization.

- To develop Specifications and Regulations for recycled materials used in road construction and other secondary materials for building construction."

The absence of a construction and demolition strategy in has contributed to the increase in environmental problems. One objective of this research, is to better illuminate the waste stream and propose a Portuguese Strategy. The absence of the strategy has lead to inefficient management of raw materials and resources. It has created difficulties in the dissemination of information on sustainable construction and the improved management of sand, clay, water and energy and other construction resources.

The low raw material extraction taxes for example for sand from rivers and beaches highlighted the weakness. Quarries operated without clear legislative control or inspection. Insufficient monitoring allows unacceptable environmental crime to take place which sometimes goes unpunished. It maximised the financial return to the business but creates environmental problems for the community. Plate 8.1 shows a mechanical excavator extracting sand from a beach, for civil construction in the Central Portugal. Due to significant efforts in education and the dissemination of information and involvement of the public the situation is changing. These practices are increasingly seen to be unacceptable creating pressure to move to more sustainable practices. The Inspectorate General for the Environment has a special role in preventing the theft of these natural resources.

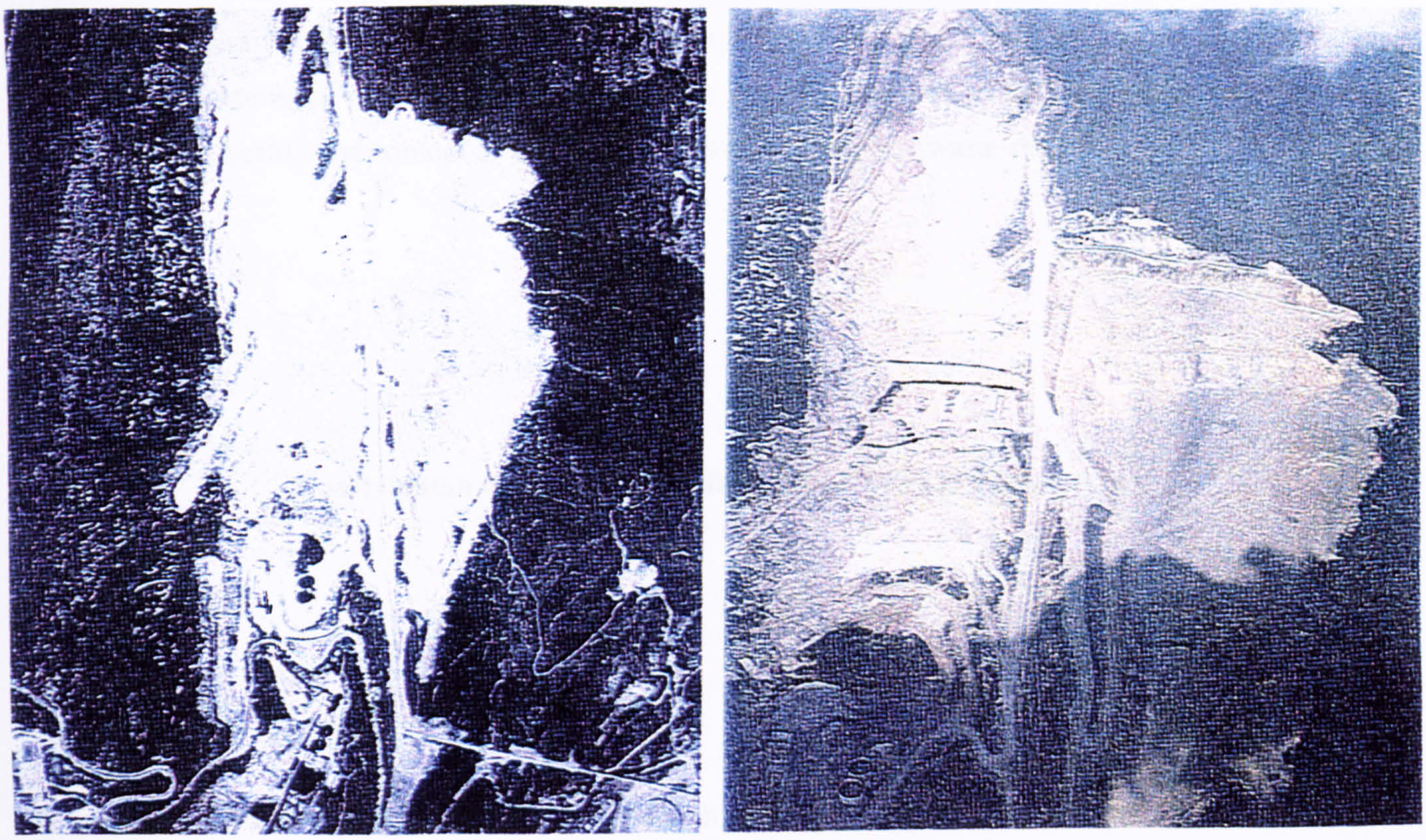
Plate 8.1 – Beach sand extraction in Central Portugal

Source: Silva and Farinha 1996:Fig.3:64.

The practice of extracting sand from the sea and beaches has created serious problems. It has weakened the dune structure and allowed coastal erosion and destruction of buildings. Insufficient planning of urbanisation close to the coast has exacerbated the problem. Serious problems to local environmental ecosystems have also been created by inappropriate sand extraction from rivers.

Inland sand and stone in quarrying and other raw material extraction has also created environmental damage. The damage is more serious when the quarries are inside Natural Parks or other environmentally sensitive areas. There is an example inside the Arrabida Natural Park. The quarry is about 50km South of Lisbon near the coast and 8 km from the city of Setúbal. It supplies a local cement factory (Silva and Farinha 1994) (see Plate 8.2).

Plate 8.2 – Quarry exploration at the Arrábida Natural Park



Source: Silva and Farinha 1994:Fig 4:65.

This quarry and the Outão cement plant, are both inside the Arrábida Natural Park, and both belong to a public cement company. There is a need to terminate this activity which contravenes European Union Directives. Raw material extraction taxes, landfill disposal levies and recycling construction and demolition waste will be fundamental to the closure of such activities. Vieira (1997) highlighted the necessity of recycling construction and demolition wastes in Portugal. Other studies (Barrit 1997, Rockliff 1997) have also stressed the need for alternative aggregate sources to mitigate the quarrying problems. The use of low-grade quarry products, reclaimed aggregates and inert waste, as highway earthwork materials would reduce the increasing demand for fresh quarry materials. The absence of fieldwork data and knowledge of the construction and demolition waste stream hamper the development of policy and action in this area.

Before considering the response to the absence of fieldwork data and knowledge it is necessary to explore the Lisbon urban form and building types. This will illuminate the characteristics of the city and give insight into the issues that will determine the quantity, quality and content of the construction and demolition waste stream.

Construction and Demolition Recycling Plants in Lisbon Area

The problems related to construction and construction management in the Lisbon area are serious and urgent. The lack of fieldwork data and knowledge of the construction and demolition waste stream has been addressed by a pilot study with the author of this study acting in an supportive role (Procesl 1997). The study was designed to inform a national construction and demolition strategy as a first step towards a Portuguese strategy on these issues. The pilot study enabled estimates to be produced of the total construction and demolition waste production and the materials in the waste stream. Those estimates are presented in Table 8.2.

Table 8.2 – Construction and demolition. Estimates from 1998 to 2002

	1998	2002
Total quantity	680 ton/day	680 ton/day
Average global characteristic		
Inerts	98,4%	95,5%
Timber	0,6%	1,2%
Ferrous metals	0,5%	0,2%
Non ferrous metals	0,1%	0,,8%
Plastics	0,1%	0,01%
Paper and cardboard	0,1%	0,01%
Others inerts	0,2%	3%

Source: Procesl 1997:90.

Quantities of construction and demolition waste were based on the application of *per capita* multipliers. Procesl (1997), demonstrates that the quantities of construction and demolition waste arising will support a recycling plant (Table 8.3).

Table 8.3 – Construction and demolition waste quantity estimates from 1998 to 2002

Materials	Quantities (ton/year)				
	1998	1999	2000	2001	2002
Inert	209 435	207 891	206 348	204 805	203 262
Paper and cardboard	213	165	117	69	21
Plastic	213	165	117	69	21
Timber	1 277	1 596	1 916	2 235	2 554
Metal ferrous	1 064	905	745	585	426
Metal non ferrous	213	202	192	181	170
Others inert	426	1 916	3 405	4 895	6 385
TOTAL	212 840	212 840	212 840	212 840	212 840

Source: Procesl 1997:122.

Table 8.4 shows the estimated quantities of inert waste collected and the landfill capacity required to receive the waste trail from 1998 to 2002.

Table 8.4 – Estimate of landfill requirements

Volume	1998	1999	2000	2001	2002
(a) total wastes collected m3/day *	486	486	2486	486	486
(b) Inert from wastes m3					
(b.1) daily volume	478	475	471	468	464
(b.2)two products volume	28 684	28 489	28 285	28 052	27 848
(c) total to landfill disposal					
(c.1) annual volume	28 693	28 489	28 285	28 052	27 848
(c.2) volume accumulate	28 693	57 183	85 468	113 520	141 368

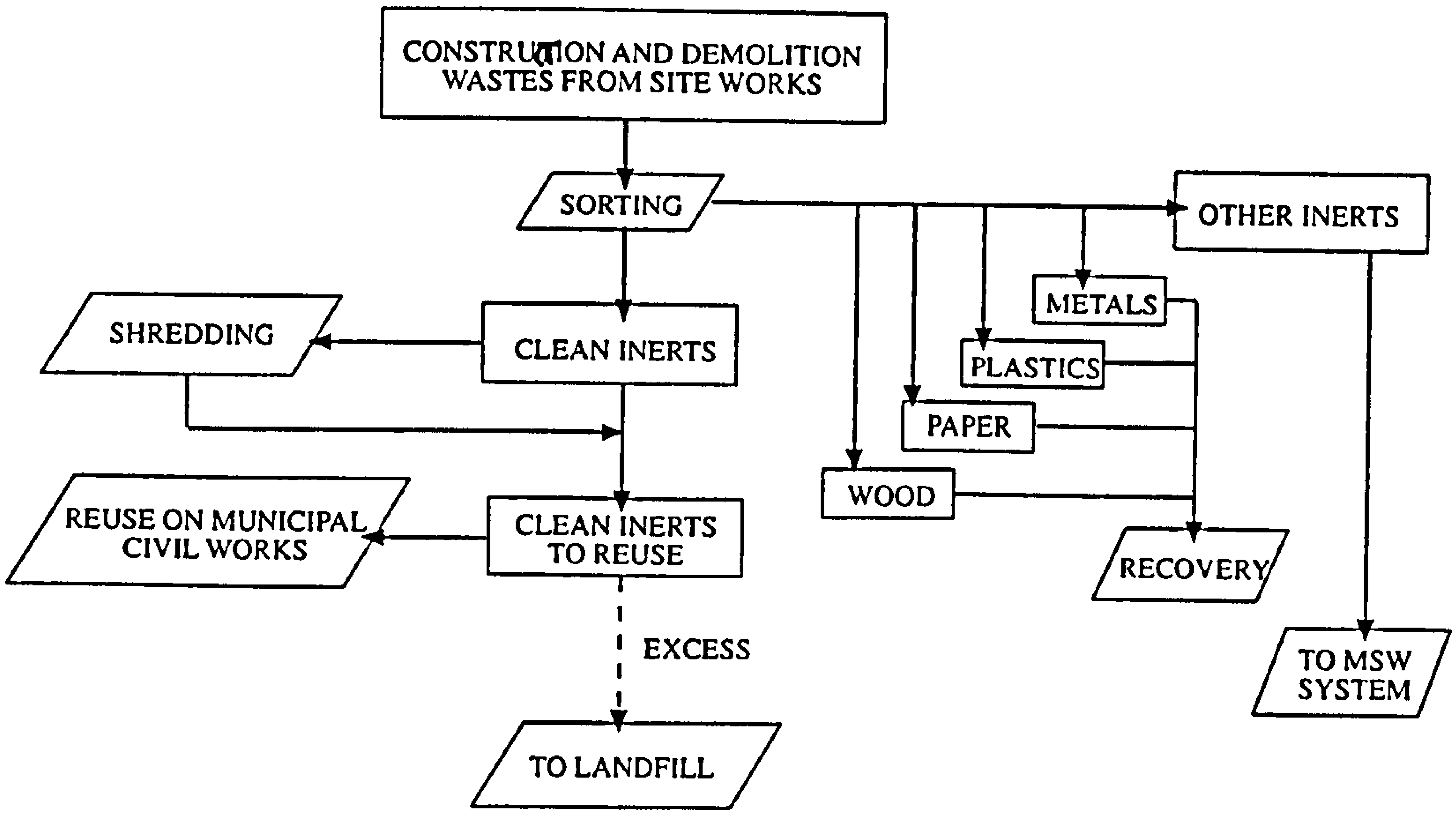
In 365 days/year
Source: Procesl 1997.

The study defined a solution for the Lisbon area and stressed the need for a recycling plant in Lisbon, demonstrated its feasibility and defined the characteristics of a company to develop the project.

Four main issues were highlighted for carefully evaluation. One issue concerns the evaluation of the technical perspectives of the recycling plant. It addresses the type, number and capacity of units and the method by which they are procured. Interlaced with that concern is the issue of siting the recycling plant and whether it should be semi-mobile or fixed. The evaluation of the economic feasibility of the project will be a fundamental to the decision. If those concerns are satisfactorily addresses then the management scenario of the investment will need to be resolved.

A flow chart of the proposed Lisbon area recycling plant is presented in Figure 8.7.

Figure 8.7 – Preliminary Lisbon area construction and demolition flow chart recycling plant



Source: Procesl 1997.

The study argued that the support and understanding of Lisbon Local Authority would be essential to the success of the project. The Lisbon Local Authority would need to develop an Action Plan with the following requirements:

1 – A priority action must be the dissemination of information and the education and training of the different actors involved in the project.

2 –The development of second markets and of appropriate Specifications and Code of Practices also need be a priority. Building and civil engineering tenders and contracts need to clearly specify the responsibility for maximising reuse and recycling.

3 – There is a need to design the Lisbon area recycling, construction and demolition plant, with flexibility to accommodate changes due to the lack of

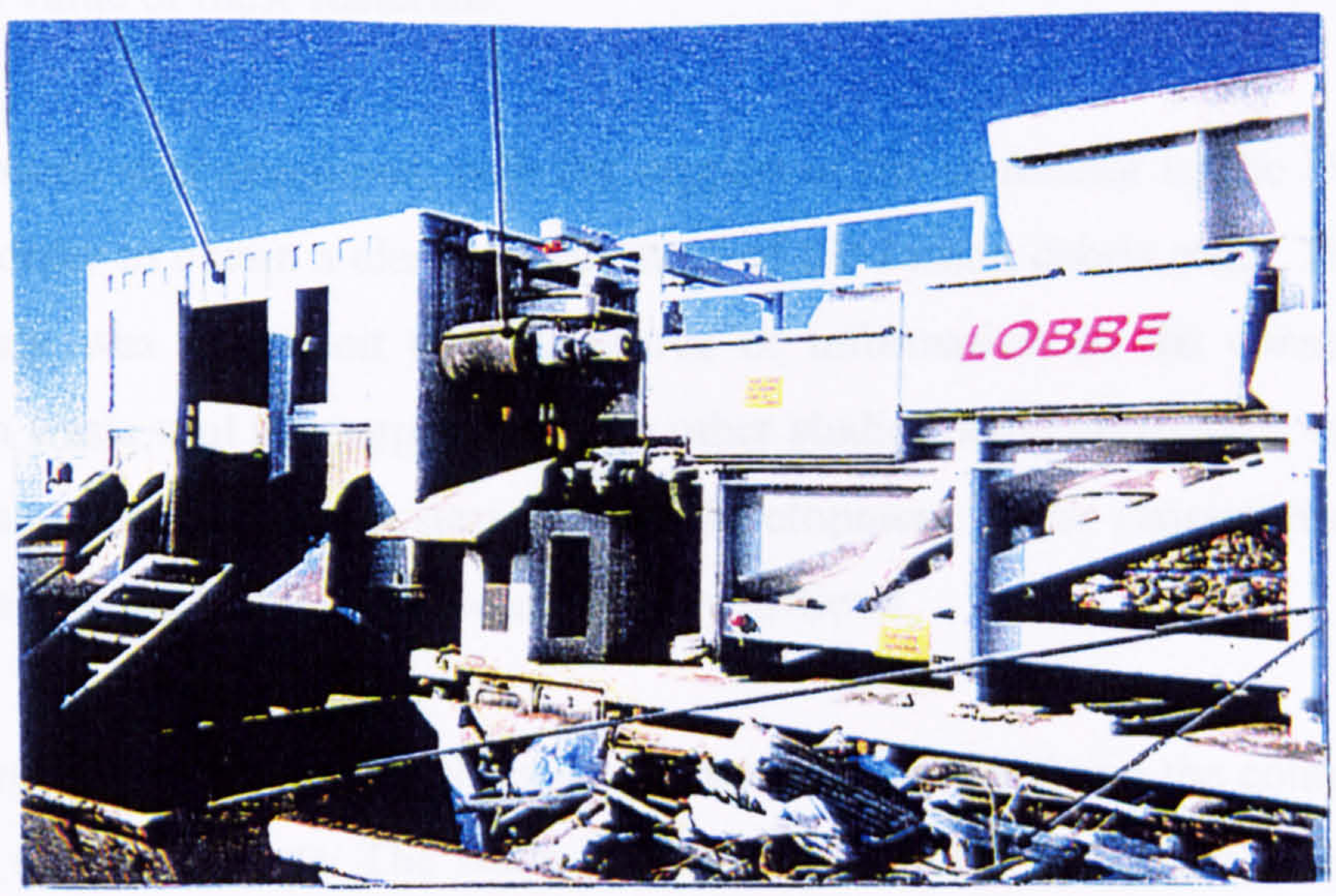
accurate data. There is a need to make adequate provision for materials without any practical reuse to be landfilled.

4 – A programme of systematic data collection from different homogenous areas and different types of buildings needs to be started. Auditing of the data must be classified into the dismantling and selective demolition phases. Sample materials must be weighed characterised and evaluated accurately.

The actions resulting from the study would be used as a pilot for the development of similar solutions in other geographical areas of the country. These other project would be developed within a national strategy based on the proposals set down in this thesis.

The only recycling plant working at the moment in the Lisbon case study area is a mobile recycling plant (Plate 8.3). The facility belongs to a private contractor Lobbe Derconsa SA (1997) and has been working in the South Lisbon area since 1989. The plant has the capacity to recycle 500-tons/day of construction and demolition waste and requires five workers to work it at full capacity.

Plate 8.3 – The Recycling Plant in Lisbon area (South)



Source: Lobbe Derconsa SA 1997.

The construction and demolition waste stream at the plant is sorted as follows:

- Ferrous metals (15 – 20 tons/month). After compaction metals go for recycling to the steel industry.

- Paper and Cardboard (200m3/month non-compacted). It is difficult to recycle due to mixture and contamination.

- Plastics (80 – 100 m3/month non-compacted). It is difficult to recycling due to mixture and contamination.

- Timber. Timber is recycled and sold as solid combustible.

- Inert materials. Some are sold for landfill cell covering and for backfilling in wastewater civil works. The remainder is sent to inert disposal.

The lack of political, institutional and environmental regulations and specifications for secondary aggregate materials is a key determinant to increase the value of these materials.

A study was developed, with the support of the contractor Lobbe Derconsa SA (1997) in order to obtain a clearer understand of the Lisbon debris trail. The objective of the study was to exploit another source of information on the construction and demolition waste trail to compare with the other studies being undertaken in the Lisbon area. It was understood from start that the development of the characterisation of the waste stream in the Lisbon area would be very difficult.

Two fundamental difficulties were created when involving the contractor. They were both related to costs. The study created delays in the operations, which was not matched by additional payment. The audit of the materials created a need for more containers and more training and qualified labour. The study was conducted from January to August 1998 using the same methodology as the pilot study. The components and materials were separated and containers were weighed and classified on site at the end of the morning and again at the end of the afternoon. The construction and demolition waste transported to the recycling plant was also audited. The results were as follows:

A – Trips undertaken with different containers:

. Total number of trips recorded................................ 24,644 un.

. Total number of trips with $6m^3$ container................ 15,740 un.

. Total number of trips with $4m^3$ container.....................8,904 un.

. Total tonnes hauled to Recycling Plant and to disposal:

. With $6m^3$ container..62,330.4 ton.

. With $4m^3$ container..19,588.8 ton.

B – Characteristics of the construction and demolition debris between January and August 1998.

The average amount entering the recycling plant was 10,240 tonnes/month calculated by extrapolation. The characteristics and quantities are shown in Table 8.5.

Table 8.5 – Results from the study in the Lisbon area undertaken from January to August 1998

Composition	Tonnes	Percentage %
Paper and cardboard	13.36	.0.15
Ferrous	25.60	0.25
Aluminium	2.05	0.02
Plastics	5.12	0.05
Timber	1,269.76	12.40
Rubble	1,556.48	15.20
Concrete, masonry, soil	7,365.63	71.93
TOTAL	10,240.00	71.93

Source: Lobbe Derconsa SA (1997)

These results do not show the true characteristics of the waste stream. The containers that arrived at the recycling plant without material being recorded that was separated out and sold on site to uncontrolled second hand markets. It was also not possible to sort on site the mixture of concrete, masonry and soil. The results obtained do not therefore truly reflect the composition of the waste trail. Notwithstanding these deficiencies it is important to note that this was the first collaborative work between contractors and researchers in Portugal investigating the characteristics of the waste stream.

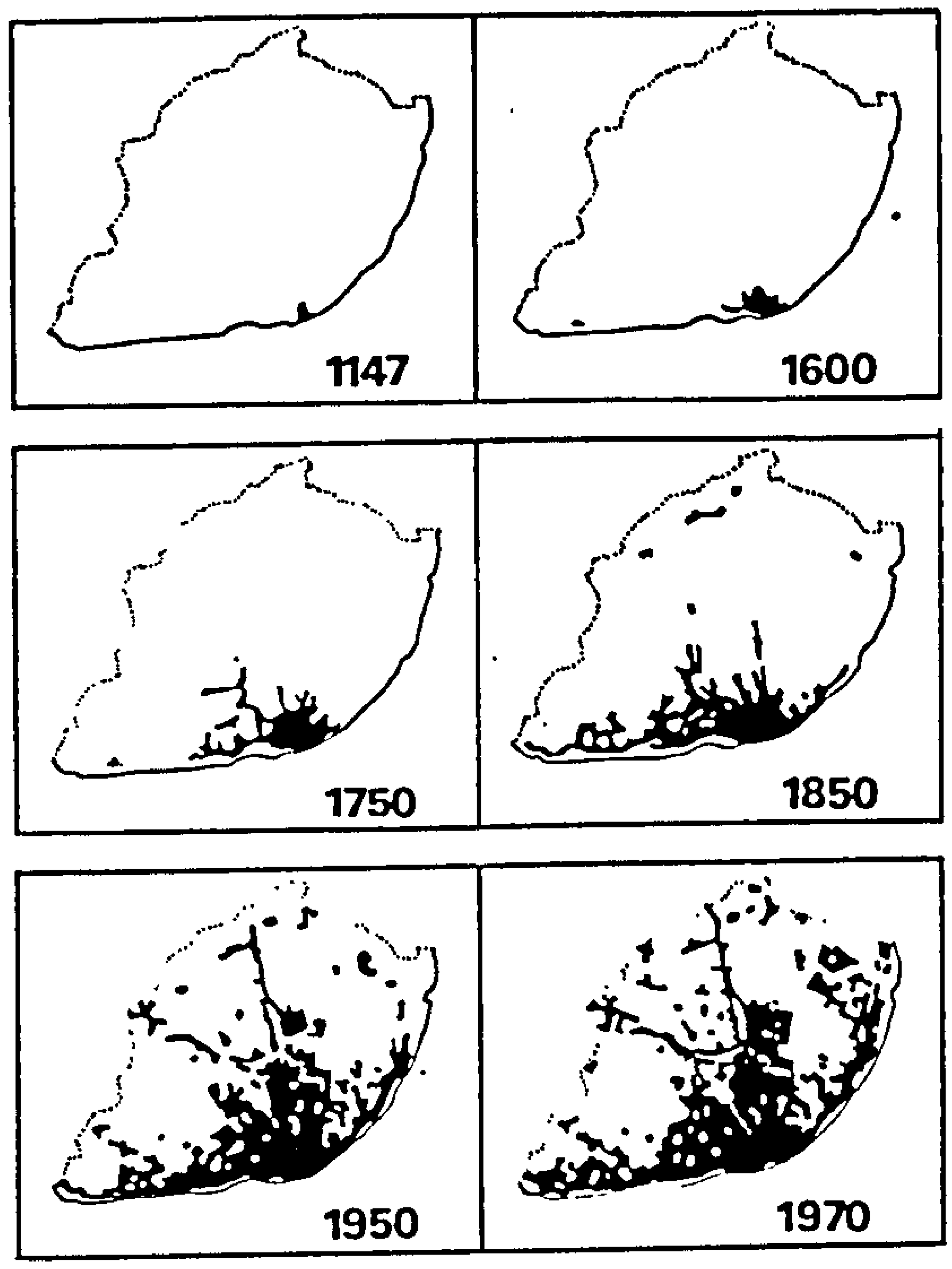
In the USA Yost and Halstead (1996) were attempting to resolve a similar problem. They were critical of the work from the USEPA (1990) "Municipal Solid Waste in the Unite States". Donavan (1990) also states that "the more we looked into it, the more we concluded that there are, in our opinion, no dependable figures or accurate information regarding generation rates or disposal practices at national level". The Yost and Halstead study posited a new methodology to estimate and quantify the volume of construction waste. It was based on the financial value of building permits for a variety of types of construction projects. Yost and Halstead (1996) developed the study, in the Boston Metropolitan area, to compare the population evaluation method of estimating the waste trail with a method based on construction and demolition permits. The study illustrated that construction and demolition activity fluctuates widely for the same period when population remains almost constant. The per capita multipliers were shown to be suspect in estimating quantities of waste generated and were no substitute for the absence of data.

SECTION 2: THE PERTINENT CHARATERISTICS OF THE LISBON AREA IN THE CONTEXT OF THE RESEARCH

Urban characteristics of Lisbon

Lisbon has been inhabited since the earliest times. Celts, Romans, Visigoths and Arabs have at various times inhabited the area. Portugal became an independent country in 1193. Portugals first king D. Afonso Henriques took the city of Lisbon from the Moors in 1147. It became the capital of the kingdom in 1255 due to its favourable position in relation to the river Tejo (Tagus) and the sea. In the 15th, 16th and 17th centuries Portuguese navigators sailed from the city to discover far distant lands. They changed it into an international trade centre for the merchandise that flowed from the newly discovered lands. Lisbon of today retains traces of that colonial empire capital (ANA 1996). The identity and expansion of the city through the centuries reflected the characteristics and culture of its inhabitants. Figure 8.8 shows the expansion of the Lisbon area over the last eight centuries (AAP 1988).

Figure 8.8 – Lisbon expansion over eight centuries



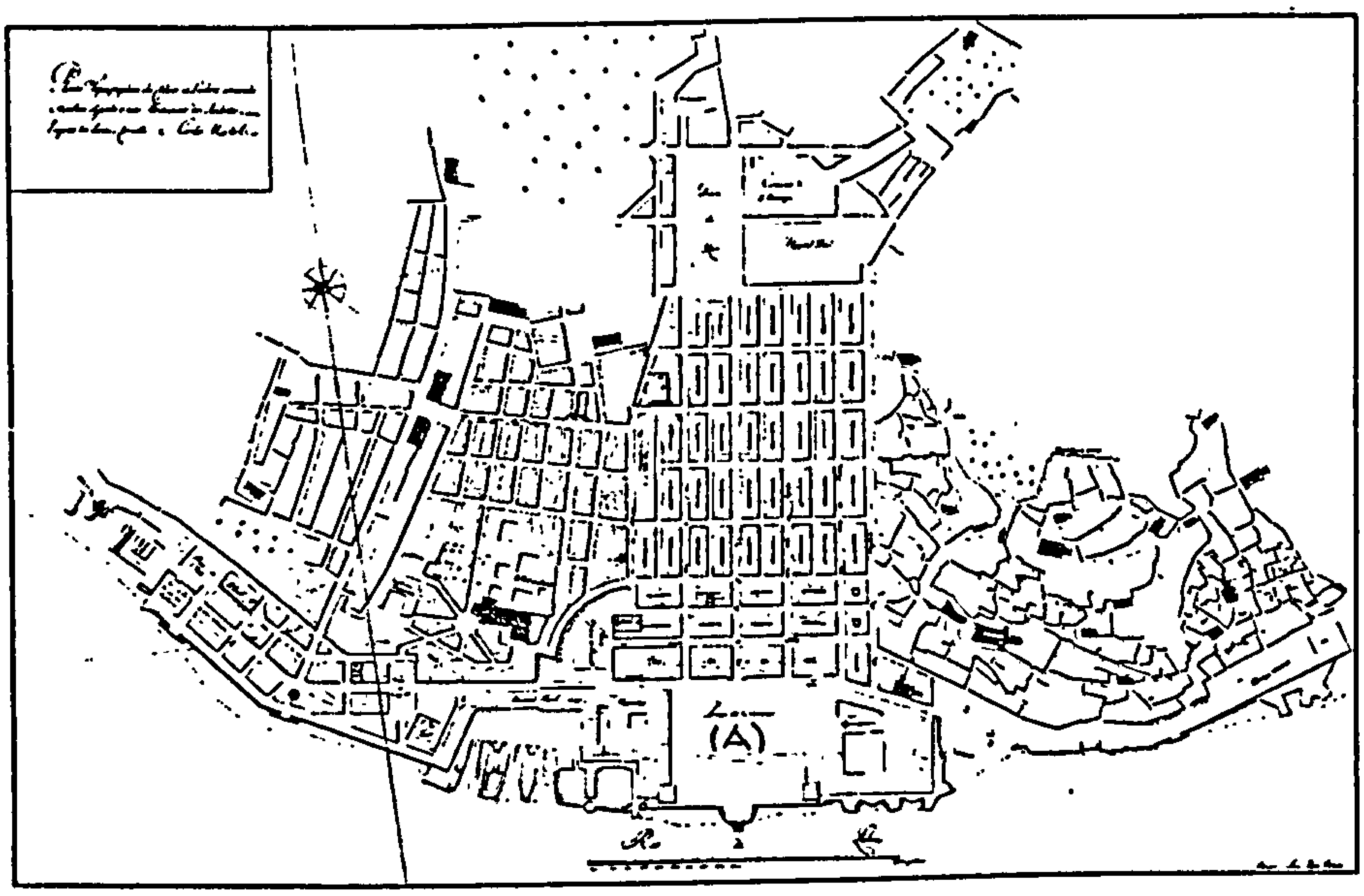
Source: AAP 1988: 12.

The earliest recorded Lisbon urban plan is from the 16th century. The Royal Palace built near the River Tagus and the Terreiro do Paço Square appear on the map and still exist in the modern city. New palaces and new buildings were built in the downtown valley of Baixa. The city expanded into the adjacent rural areas. Bairro Alto, on a nearby hill, was the first planned part of the city. In 1755, a big earthquake caused significant destruction, and prompted a period of construction and reconstruction known as the "Pombalino Style". The "Pombalino style" marks a period of great infrastructure works and developments, but also a reconstruction period after the big earthquake of 1755. With the earthquake many parts of the country were affected. The capital was seriously destroyed by the earthquake but also by the fire and the tidalwave after it. King Jose I, supervised the re-building undertaken by his powerful Prime Minister Sebastião José de Carvalho e Melo, the Marquis de Pombal, and his team. The period was marked by the high level of forward looking construction.

The coherence and the homogeneity of the Pombal plan, is derived from the cruciform lines and streets, from the proportion and placement of its building plot and from the symmetry of its building projects, both in terms of the design of its façades and the layout of its internal courtyards (AAP 1988).

Figure 8.9 shows the initial 1975 design of downtown Lisbon based on the "Pombalino style" and Terreiro do Paço Square (A).

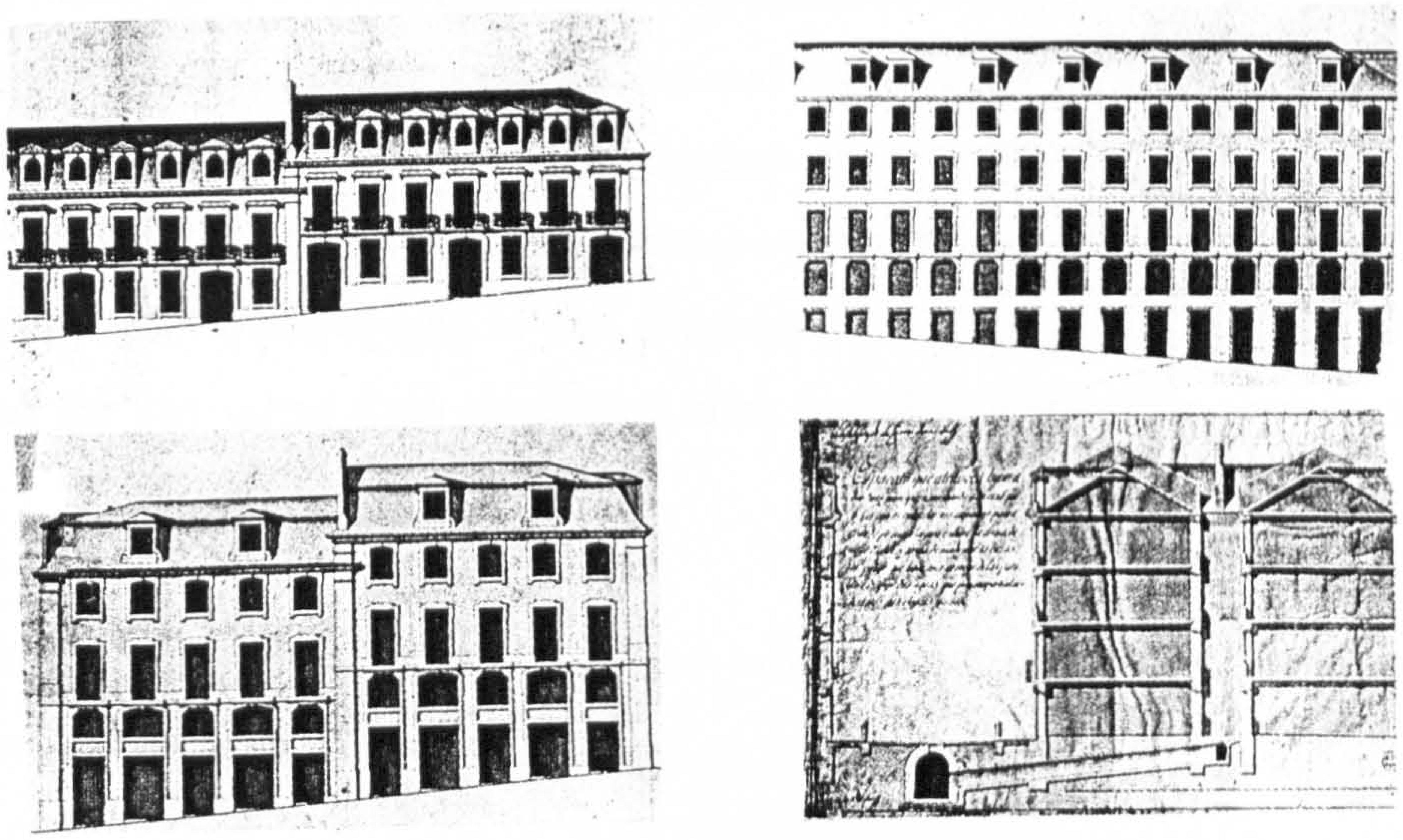
Figure 8.9 – Lisbon downtown on "Pombalino style" and the Terreiro do Paço Square (A). Design from the initial project in 1755



Source: APA 1988.

Figure 8.10 gives an image of the buildings with "Pombalino style" façades, as well as the building's sewer system to the manhole and the main sewer in the centre of the road.

Figure 8.10 – Buildings in "Pombalino style" façades and sewer systems to an external manhole



Source: APA 1988.

A view from Terreiro do Paço square and downtown "Pombalino style" Lisbon is shown in Plate 8.4.

Plate 8.4 – Terreiro do Paço square today

Source: AAP 1988: 21.

The industrial revolution and the new architecture also generated a change in the city form and in the rate of expansion. The second part of the 19th century, was marked by the frame type "gaiola" building construction process. This building construction process involves building with an interior framework of timber. It is a strong structure which behaves well in earthquake as was demonstrated in 1755. Whilst the built form has changed the city urban form developed after the 1755 earthquake remains to this day.

The indicators, by civil parish of the urban Lisbon area, are summarised as follows:

1 – The resident population

2- The number of existing buildings

3 – The civil parish areas

4 – The population density

5 – The building density

Table 8.6 presents the Lisbon urban indicators by civil parish for the 1991 (Procesl 1997).

Table 8.6 – Lisbon urban indicators by civil parish in 1991

CIVIL PARISH	POPULATION (Inh/hab)*	BUILDINGS	AREA (km²)*	POP. DENSITY 4		BUID. DENSITY (Buid./km²)
	1	2	3	(Inh/km²)	(Inh/Buil.)	5
Ajuda	22 404	3 177	3,147	7 119	7	1 010
Alcântara	18 510	1 949	4,386	4 220	9	444
Alto do Pina	12 654	652	0,824	15 357	19	791
Alvalade	10 996	591	0,578	19 024	19	1 022
Ameixoeira	10 605	929	1,622	6 538	11	573
Anjos	12 490	1 009	0,478	26 130	12	2 111
Beato	17 494	2 030	1,407	12 434	9	1 443
Benfica	47 099	3 216	7,937	5 934	15	405
Campo Grmde	12 146	627	2,438	4 982	19	257
Campolide	20 972	3 797	2,790	7 517	6	1 361
Carnide	11768	1 831	4,017	3 676	8	456
Castelo	773	134	0,054	14 315	6	2 481
Charneca	9 572	1 466	1,704	5 617	7	860
Coração de Jesus	5 379	558	0,542	9 924	10	1 030
Encarnaç:ão	3 072	503	0,148	20 757	6	3 399
Graça	8 604	817	0,341	25 232	11	2 396
Lapa	10 656	1 073	0,721	14 779	10	1 488
Lumiar	35 390	3 456	6,282	5 634	10	550'
Míadalena	526	76	0,111	4 739	7	685
Mártires	401	50	0,096	4 177	8	521
Marvila	47 827	3 016	6,294	7 599	16	479
Mercês	6 039	803	0,303	19 931	8	2 650
Nossa Senhora de Fátima	18 611	1 296	1,866	9 974	14	695
Pena	7 045	694	0,494	14 261	10	1 405
Penha de França	17 885	1 468	0,664	26 935	12	2 211
Prazeres	10 068	1 463	1,482	6 794	7	987
Sacramento	1 167	165	0,081	14 407	7	2 037
Santa Catarina	5 153	727	0,209	24 656	7	3 478
Santa Engrácia	7 626	763	0,567	13 450	10	1 346
Santa Isabel	9 249	1 085	0,619	14 942	9	1 753
Santa Justa	1 152	182	0,238	4 840	6	765
Santa Mariade Belém	12 092	2 280	3,388	3 569	5	673
Santa Maria dos Olıvais	51 367	3 184	10,662	4 818	16	299
Santiago	1 226	133	0,062	19 774	9	2 145
Santo Condestável	22 186	2 719	1,011	21 945	8	2 689
Santo Estevão	3 192	411	0,183	17 443	8	2 246
Santos-o-Velho	5 534	957	0,508	10 894	6	1 884
São Cristovão e S. Lourenço	2 442	229	0,077	31 714	11	2 974
São Domingos de Benfica	35 125	1 671	4,296	8 176	21	389
São Francisco Xavier	8 665	1 059	2,102	4 122	8	504
São João	21 960	1 786	1,564	14 041	12	1 142
São João de Brito	17 143	1 374	2,275	7 535	12	604
São João de Deus	13 309	843	0,902	14 755	16	935
São Jorge de Arroios	23 051	1 652	1,134	20 327	14	1 457
Sao José	4 430	585	0,340	13 029	8	1 721
São Mamede	7 072	643	0,596	11 866	11	1 079
São Miguel	2 613	356	0,05S	45 052	7	6 138
São-Nicolau	1 448	203	0,247	5 862	7	822
São Paulo	4 676	506	0,406	11 517	9	1 246
São Sebastião da Pedreira	7 842	571	1,054	7 440	14	542
São Vicente de Fora	5 453	629	0,308	17 705	9	2 042
Sé	1 926	193	0,121	15 917	10	1 595
Socorro	4 309	454	0,108	39 898	9	4 204
CITY OF LISBOA	663 394	62 041	84	7 912	11	740

Source: Procesl 1997:32.

Using figures from Table 8.6 it is possible to classify the civil parish by building density as follows (see Table 8.7):

Table 8.7 – Building density by civil parish

ORDER NUMBER	CIVIL PARISH	BULDING DENSITY (Building/sq.Km)
1	São Miguel	6138
2	Sé	4204
3	Santa Catarina	34 78
4	Encarnação	3399
5	São Cristovão e São Lourenço	2974
6	Santo condestável	2689
7	Mercês	2650
8	Castelo	2481
9	Graça	2389
10	Santiago	2145

S. Miguel has the highest building density, 6138 building/sq. Kilometre, which corresponds to an area of new building development. The civil parish with lower densities have older buildings. Using these indicator it will be possible to forecast the amount and characteristics of the construction and demolition waste deriving for activity in each of the areas.

The population of Lisbon in 1991 was nearly 650.000 resident inhabitants. Around a third lives in five periphery civil parishes: Benfica, Lumiar, Marvila, Santa Maria das Olaias and S. Domingos de Benfica. 14 of the 53 civil parishes have resident populations of less than 5.000 inhabitants which is less than 5 % of the total city population (Procesl 1997). The civil parishes with the largest number of existing buildings are on the periphery.

Types of buildings in Lisbon

A study focused on the different building types and the different periods was developed by the Lisbon City Council and the National Laboratory of Civil Engineering (Cabrita, Aguiar and Appleton 1993). It consider four main classifications. Two further classifications can be added. They are the provisional municipal quarters which provide temporary shelter for homeless and poor families, and the clandestine slums. The Local and Central authorities are making concerted efforts to bring the social and environmental problems associated with these development under control by the new millennium. The study identified four types of buildings in the Lisbon area:

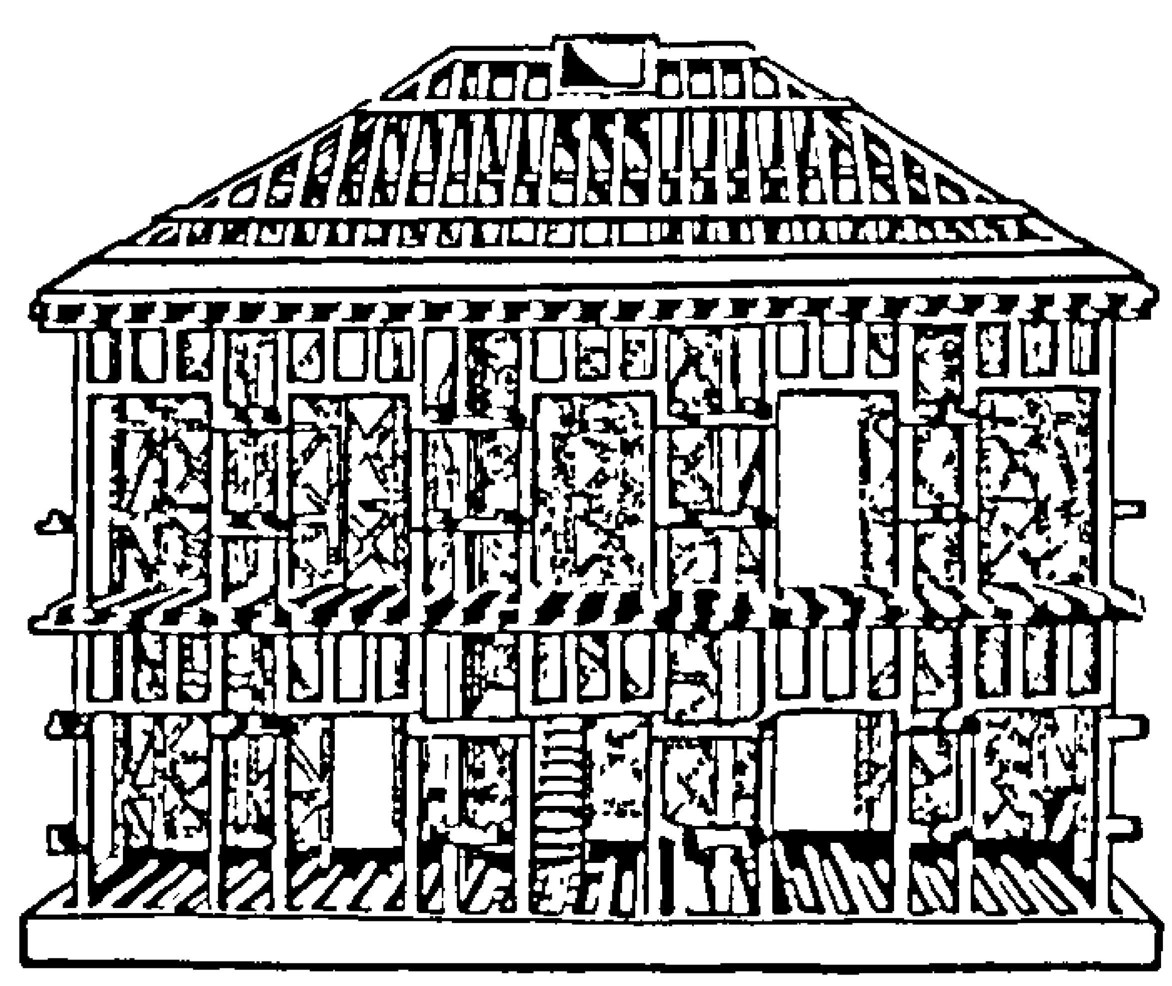
Type 1 – Before the earthquake of 1755

This type of building was built prior to the 1755 earthquake. There are two subgroups. The first which constitutes a smaller number of buildings are constructed of masonry walls with stone corners and pilasters. The floors are made of timber supported by arches sometimes reinforced with timber beams. The roofs are supported by full brick barrel vaults. The second subgroup is more numerous. It derives from rural construction. It has thick walls, thicker on the ground floor, and poor masonry. The timber floors are supported on beams supported the facade walls. Some buildings have a structural timber frame infilled by a mixture of masonry. The buildings have metal bolts on their corner walls. They normally are one or two storeys but sometimes more (Cabrita, Aguiar and Appleton 1993).

Type 2 – Buildings with structural masonry

This type involved new structural and construction technologies. The buildings normally had three floors and a "mansard", garret or attic room in the roof space. The structural timber frame was generally made of chestnut. The outer walls, were made of masonry, built with bricks or small stones, externally rendered. Timber framed partitions were used to divide the internal space. Prepared stone was used in the wall corners and pilasters. Figure 8.11 shows the structural timber framework of the two storey building (Cabrita, Aguiar and Appleton 1993).

Figure 8.11 – The first two floors building timber framework in "Pombalino style" design



Source: AAP 1988.

Type 3 – Buildings with masonry as a structural support but with a timber frame (the fourth part of the XIX century till about 1930)

This type of building resulted from gradual development of the Pombal structural system. In this period the buildings were up to five or six storeys with modified structural timber frame. There is three dimensional structural continuity in the timber frame. Cabrita, Aguiar and Appleton (1993) summarised the structural system as follows:

- Three kinds of walls exist: the principal walls are masonry using irregular stones; secondary load bearing brick walls and internal timber framed partition walls. The ground floor internal walls are all load bearing. All load bearing walls have hard stone masonry foundations set below the ground surface.

- The floors are timber on timber frame.

- Up to the middle of the 19th century a kitchen extension was built. The structural frame was of cast-iron beams and columns.

- From the 19th century many buildings had iron beams on the first floor for larger spans. Ground floor load bearing were then omitted.

Type 4 – Concrete construction (since 1930 to present time)

Concrete in construction has three phases:

- The first phase derived from the first Lisbon Council General Urban Construction Regulations. Concrete was required for toilet and kitchen floors and for annexes such as balconies, roofs and staircases. It was considered more desirable and compatible with a reinforced concrete frame for these floors to be built with non-inflammable and non- putrescible materials. It produced mixed structure buildings with concrete in areas of humidity and timber elsewhere.

- The second concrete phase was from the 1930s to the 1950s. This was a period of the total integration of concrete into the structural systems. It was a period of change from the mixed structures to total reinforced concrete structures. Walls were made with double brick thick masonry external walls and single brick thick internal walls. The buildings were around six to eight storeys.

- The third concrete phase from the 1960's, is characterised by larger span buildings, taller and of specific use types (Cabrita, Aguiar and Appleton 1993).

The information and knowledge about the type of buildings facilitates the forecasting of the quantity and quality of the construction and demolition waste trail.

Homogenous building areas in Lisbon

The knowledge of homogenous building areas in Lisbon, will also facilitate the forecasting of the quantity and quality of the construction and demolition waste trail.

Some concerns were expressed in previous studies about the definition of homogenous building areas. Procesl (1997) pointed out that these areas should present a set of common characteristics, under the following criteria:

- areas where a dominant type of building is found, built in the same period and consequently with the same construction system.

- urban areas with the same characteristics where buildings do not have more than two floors.

- Other kinds of characteristics for example slum areas, or any other common characteristic.

The criteria was followed for several homogenous areas based on an analysis of three difference sources. They were:

- The Plano Director Municipal (PDM), the Municipal Master Plan.

- The city urban and morphologic areas analysis.

- Data analysis from the National Statistic Institute (INE 1998) census.

The first step of the survey was the analysis of the areas referred to in the Municipal Master Plan. Residential areas were identified from the plan. The study demonstrated that the principal volume of construction and demolition waste arose from these areas. The historic residential area was also studied. It is an area where many buildings still remain that were built before the 1755 earthquake, and many others that were built immediately after the catastrophe. The Municipal Master Plan analysis enabled some areas with specific characteristics the identification such as single family dwellings and areas of urban rehabilitation.

The study of the historic evolution of the city's urban areas and the knowledge of the different kinds of construction systems used, assists a better understanding of the relation between the construction system and the different areas. Whilst the areas are defined as homogenous, it must be noted that there are buildings which do not conform to the norm in each of the areas. They are by definition exceptional. This inherent deficiency does not prevent the to be civil parish, the "freguesia", from being the relevant unit of analysis. Using the INE data, it is possible to relate the characterisation of an area with the construction materials, and consequently the characteristics of the demolition trail. There is a direct relationship between the debris trail and the main elements of the building construction. The Lisbon civil parish map distribution is presented in Appendices X (Procesl 1997).

Finally, the importance of the study, has been to identify special areas where rigorous knowledge exists of the changes under taken in the last five years. The areas of the "Gabinetes Técnicos Locais" (GTL), Local Technical Offices and the "Planos Especiais de Realojamento" (PER), Special Re-accommodation Plans. The knowledge of the investment in urban rehabilitation in quarters under the Local Technical Office, marks them out for specific study. It records accurate information of the development works occurring on those sites. These are areas of great construction activity have created significant debris trails. It is foreseen that in the following years a significant increase in investment in those areas, will produce a large volume of civil works.

Under the Local Technical Office management, there are four historic quarters in the city's central area, together with five periphery nucleus and a quantity of at least one hundred "páteos" and "vilas" and small settlements. Historic buildings were built in Alfama, Mouraria, Bairro Alto and Madragoa. Periphery nucleus are built at Carnide, Paço Lumiar, Rua do Lumiar, Ameixoeira and Olivais Velho.

The Special Re-accommodation Plans (PER) are focused on slum areas with degraded buildings. These areas are easily identified and it is possible to know exactly the number of buildings to be demolished. The PER assumed that each new house built replaced degraded house. From this information it will be possible to create a scenario of the production of demolition wastes. Two homogenous areas were studied to get a better understanding of these characteristics (Procesl 1997). The two areas are characterised below.

AREA 1 – Residential historic area

This area has a significant diversity of buildings from Middle age to the present day. The older buildings extended from the area of S. Jorge's Castle to the Tagus River and Alfama and Mouraria that occupy all the riverside stretching to Alcantara. Older buildings also exist on the Santa Ana hill and they occur in dispersed nucleus near the old roads and old access paths that served the ancient city centre. The old nucleus of Campo de Ourique, S. Sebastião, Calhariz de Benfica, Benfica, Carnide, Telheiras, Paço do Lumiar, Ameixoeira, Charneca, Olivais, Chelas and some more old nucleus at the eastern and western side near the river also contain buildings of similar characteristics. Until the 1755 earthquake, the city expanded in an uncontrolled way. The exceptions, which were planned and managed were Bairro Alto and Madragoa areas built in the 16th century under the control of the Local Technical Offices.

After the 1755 earthquake, development occured in accordance with the "Pombal Plans". Lapa, Amoreiras, Alegria, S.Paulo and Bairro das Flores were developed in this way. Baixa, the medieval centre was rebuilt in accordance with Pombal Plans. These developments, when eventual demolished, will produce wastes very similar to those found in earlier structures, but with a higher percentage of timber.

The INE (1998) data, shows Pombal Plan buildings represent percentages of the total buildings of between 100% in Madalena and Mártires civil parishes and 51.7% in S. Nicolau civil parish. These values are quite different to the values we find in other civil parishes where the buildings present identical construction characteristics. In the historic residential areas, the building with these characteristics, represent about 81% of the total of 14,591 buildings. About 9% of the buildings in the periphery civil parish of this nucleus have a concrete frame. The civil parishes are the Anjos, Coração de Jesus, Lapa, Prazeres, Santa Engrácia and Santa Isabel.

AREA 2 – XIX century second half-residential areas. The quality of the timber framework solution

By 1875 the Pombal Plans for the city of Lisbon had not been completed and it was abandoned. From about 1850, a new urban policy was introduced resulting in different development characteristics. These new developments took place in the second half of the 19th century, and the first decades of the XX century. The areas conforming to the new 19th. century urban approach were Campo de Ourique, Estefânia, Camões, Calvário, Rua da Palma, Campolide, "páteos" and working men's "vilas".

The Avenida da Liberdade (Liberty Avenue), enlargement was finished in the year 1886 and was responsible for the city's expansion to the North with the new avenues. The Queen D. Amelia Avenue and Almirante Reis Avenue were completed in 1903 together with the areas from the Intendente to Estefânia. The buildings in these areas were quality timber framed construction characterised by a symetrical floor type and with a height of between 4/6 floors. Similar types of buildings but of concrete construction were built after 1930 (Cabrita, Aguiar and Appleton 1993).

A weakness in the data from the INE (1998) is that there is no clear distinction between buildings constructed from the last quarter the 19th century onwards and the older buildings. In order to improve the data, that distinction was made. The earlier buildings were classified as buildings with quality timber frame. The later buildings were classified by the nature of the resistant elements and the number of floors. Table 8.8 sets down the data by that classification.

Table 8.8 – Buildings with concrete structure, resisting wall and stone structure by number of floors and by civil parish

CIVIL PARISH	Resistent Elements										Total of build.
	Concrete		Resistant walls						Stone		
	Total	% (total)	1 to 3 floors	4 to 7 floors	1 to 3 floors total (%)	4 to 7 floors total (%)	4 a 7 floors (%)	Total By Civil parish	Total	% (total by civil parish)	
1. Alcântara	373	19	1096	802	294	73	27	15	108	6	1949
2. Alto Do Pina	199	31	364	180	184	49	51	28	32	5	652
3. Anjos	155	15	495	209	286	42	58	28	356	35	1009
4. Campolide	1378	36	1941	1731	210	89	11	6	332	9	3797
5. Graça	101	12	530	315	215	59	41	26	146	18	817
6. Nossa Senhora De Fátima	513	10	668	286	382	43	57	29	77	6	1296
7. Pena	60	9	506	266	240	53	47	35	45	7	694
8. Penha De França	325	22	835	536	299	64	36	20	262	18	1468
9. Prazeres	117	8	1051	847	204	81	19	14	128	9	1463
10. S. João	533	30	1001	779	222	78	22	12	170	10	1786
11. S. João De Deus	374	44	305	117	188	38	62	22	162	19	843
12. S. Jorge De Arroios	561	34	656	151	505	23	77	31	380	23	1652
13. S. Mamede	91	14	279	110	169	39	61	26	174	27	643
14. Sebastião Da Pedreira	243	43	245	57	188	23	77	33	83	15	571
15. Santa Isabel	156	14	578	395	183	68	32	17	350	32	1085
16. Santo Condestável	407	15	1603	1293	310	81	19	11	446	16	2719
Totais	5586	25	12153	8074	4079	66	34	18	3251	14	22444

Source: Procesl 1997:46.

The next Section discusses the types of civil and building construction in the Lisbon area. The range of new residential construction, private and public non-residential construction, civil engineering works and rehabilitation are referred to giving an indication of the waste trail generated. In the last type of construction, renovation, restoration, refurbishment and maintenance works are all included.

SECTION 3: TYPES OF CIVIL CONSTRUCTION WORKS IN THE LISBON AREA

The reports from AECOPS (1998), Euroconstruct (1997) and from ECIF (1998) adopt a common approach which divides construction work into building works and civil engineering works. Building works include new residential construction and private and public non-residential construction. Civil engineering works include roads, bridges and the construction of infrastructure. Both classifications include rehabilitation works.

New Residential Construction

New residential building is mentioned in the ECIF (1998) report. Residential building construction grew sharply in response to strong owner-occupier housing demand. The construction associations reported that this segment of activity was the most favourable of the last decade averaging an increase of 10% in 1997

(AECOPS 1998). During 1997 the number of mortgage loans increased by 29 % and their combined value by 36 %, when compared with 1996. This was attributed to the drop in nominal interest rates to around 3% and to a 1.9% increase in employment (AECOPS 1998). The 1997 increase was more than 11 % in real terms. The forecasts for 1998 and 1999 are for a 5 % real growth rate. The actual figures for the period are not yet available. The rented building market behaved differently and has declined without a prospect of a reverse.

Private and Public Non Residential Construction

According to AECOPS (1998), non-residential building construction showed a very positive upward trend during 1997. Both private and public demand contributed to this better performance. In the public non-residential building sector some big public projects had a significant effect on the 14.5% increase. Private non-residential construction rose by 5.8 %. This increase was attributed to the improved performance of the economy and the resulting higher confidence level of investors creating increased private demand.

The major contribution to the performance in the public sector was the Lisbon construction of the World Exhibition (EXPO'98) which included some major buildings. Other major investments were made in health infrastructure that included the construction of the Barlavento Algarve Hospital. Investment was also made in education with the construction of several schools at different scholastic levels.

As far as public works are concerned, non-residential buildings represented about 34.9% of the value of bids and 22.6% of total contracts awarded in 1997. This was an increase of 34.2% and 112.9% respectively in real terms (AECOPS 1998). Despite the control of the public deficit and debt imposed by the Maastricht Treaty, the

EXPO'98 works led to a significant increase in public investments in this field of activity. Public investments by central, local and regional administration account for 92 % of the total investment. Public investment below central administration includes only the Madeira and Açores Islands. The investment of the other administrations is recorded as private investment. The convergence criteria established in the Mastricht Treaty and more recently in the Stability Pact are predicted to result in a 0 % growth rate in public non-residential building for 1998. The actual figures are not yet available. This represents the construction of Regional Hospitals (15.4 million PTE) and Central Hospitals (4.5 million PTE). These are the most important projects for the year. Private non-residential building, in contrast, is expected to have a 4.1 % growth rate in 1998. The actual figures are not yet available.

Civil Engineering works

The civil engineering works segment had an estimated growth of 15.5 % in 1997. It was the engine of the good performance achieved by the construction sector as a whole. The significant growths observed contributed to an increase in the importance of civil engineering works in the sector. In 1997 the output from the sector represented around 35 % of the total output against 30 % observed in 1996. It contributed to the very significant growth of 21 % in the number of bids and 47 % in the value of the contracts awarded in the sector as a whole (AECOPS 1998). This was attributed to the level of competition, which was more favourable than in 1996. The prices of the contracts awarded were only 1.1 % inferior to the initial bid prices (-8.8 % in 1996) and the number of competing contractors per awarded contract decreased from 6.7 in 1996, to 5.8 in 1997. The major slice of investments in the civil engineering works market, was once again accounted for by the Central, Local and Regional Administration. This was despite the control of the public deficit and debt imposed by the Maastricht Treaty to undertake the third phase of European Monetary Union (EM). They represented more than 97 % of total bids and contracts awarded in this period.

A natural consequence of the tightening of public sector expenditure in Portugal, as well as in the other European Union states, is that there is pressure to curtail civil engineering expenditure. For that reason Portugal is improving the participation of the private sector in public infrastructure financing. Following the estimates of the Roads Autonomous Board private investments in Design-Building-Finance-Operate (DBFO) and in Build-Own-Operate-Transfer (BOOT) in road infrastructure in 1997 was worth 11.7 million Esc. at 1996 prices and expected to reach 47 million Esc. in 1998 (AECOPS 1998). The enlargement of private sector civil engineering works assists in the reduction of regional disparities and increases the supply of road infrastructures in more peripheral zones. It accelerates National Road Plan (RNP) and reduces public expenditure on the programme.

The completion of the new bridge over the river Tagus, and the EXPO'98 and other large projects coupled with public investment restrictions will constrain civil engineering activity in 1998. Investment volume will continue despite the decreases observed in the number and value of bids and contracts awarded in the public works market during the first quarter of 1998. The construction of the new Porto Metro network, the enlargement of the Lisbon Metro network together with the expansion of the road and rail network, new hospitals, schools and the Alqueva Dam project will contribute to growth in 1998 but at a lower rate of 4.5 %.

Rehabilitation (Renovation, Restoration, Refurbishment) and Maintenance

Throughout 1997, rehabilitation and maintenance works represented a minor share, 7% of the total construction sector output. Residential building maintenance works reached 120.1 thousand million Esc. in 1997. A 5.3 % growth rate is forecast for 1998. It will not be enough to significantly improve its importance in terms of its share of the market. That will depend on the resolution of several unsolved problems related to the inefficiency of the rental system.

Civil engineering rehabilitation and maintenance, in contrast, experienced a sharp increase of 10 % during 1997 representing 79.8% of the total contracts awarded. In 1996 the figure was 71.2 % of the total value of the public contracts awarded. The growth rate figure forecast for 1998 is 4 % (AECOPS 1998).

This review has set the scene for the Lisbon area multiple case studies. Next Section concerns the development, collection of data, interpretation of data collected and considering the results. The difficulties in the development of the case studies are considered. There is a discussion about the actors' participation and involvement in the projects and of the results obtained.

SECTION 4: THE COLLECTING, INTERPRETING AND TREATMENT OF DATA FROM LISBON CASE STUDIES. DIFFICULTIES AND RESULTS

Introduction

The development of the Lisbon area case studies is important, as they are one of the sources of data drawn on to conceive, define and construct the dynamic model. The other sources were discussed in previous Chapters. It was the first significant action to collect data on construction and demolition waste stream in Portugal. The author as a Portuguese Waste Institute vice-president were a significant involvement in this process. The main goal was also to contribute to the Portuguese construction and demolition waste stream. Many actors were involved for the first time and despite difficulties with quantitative and qualitative results valuable information was gathered to inform further actions.

Difficulties and restrictions in the development of the Lisbon area multiple case studies were predictable. An attempt was made to include them in the initial assumptions and some allowance was made for them in the data collection. The social and economic environment was not sensitive to the characteristics of the waste stream. The results are more qualitative than quantitative and give insight into the difficulties of creating and implementing strategy. This will be reflected in the dynamic model.

One of the fundamental difficulties in controlling the construction and demolition or renovation process, are the difficulties in predicting the time for the fieldwork to start following the granting of the permit to do the work to the contractor. It would help if the permits could define the time for the commencement of the practical works.

The data collection was divided into two main areas. The "soft" data related to the human environment, which is linked to the different actors'participation in the project and the "hard" data on the waste stream, from the building rehabilitation fieldwork.

The Training Seminar

A seminar to explain the objectives and characteristics of the Lisbon case studies was developed. It had the purpose of explaining to all involved in the project the aims and objectives of the fieldwork. The training seminar involved a discussion of the global or conceptual concerns of the study. This was to insure that the desired level of understanding had been achieved. The difficulties that were likely to be faced by each member of the team in practice were discussed. The case study observation team was also trained to train the contractors group to enable them to understand the importance of the study, and develop the necessary practices to enable the case studies to be successfully completed. The contractors' workers would be asked to perform their tasks in a different way to enable the case study observation team to carry out their work. In the event, this was not successful and the workers were insufficiently briefed in this task.

Multiple Case Studies Development

The 1997 study was taken as a pilot study to the Lisbon multiple case study research (Procesl 1997). The pilot was based on eight building renovation sites in different places in the Lisbon municipality. It was designed to test the ability to characterise the construction and demolition waste stream. Data was collected on the waste streams over a three-day period. Data collection was based on the methodology developed by Yost and Halstead (1994) to estimate the quantities of materials in the construction and demolition waste stream. It is an alternative to the per capita multiplier. It was intended that this first intervention would give an indication of the appropriateness of this methodology, to underpin the design of a future national waste strategy.

Five case studies were chosen for the project, and data was collected using the same methodology as that used in the pilot study. The first step was to establish the objectives, develop the process of data collection and the protocols assigning the work between the parties involved. The step was completed with the convening of a seminar to disseminate the information to the actors. A member of the case study observation team explained the objectives of the study to the contractor's representatives, foreman and workers involved in the process. The second step was to visit the sites of the renovation works, and to finalise the details of the research project with the contractors.

To enable the study team to analyse and compare the contractors' attitudes and behaviour in each of the five cases they were classified in three groups according the following characteristics:

a) "Classe do Alvará" – a permit which regulates the maximum financial value of of a contract for which a firm can tenders.
b) The capital of the firm (share capital).
c) Number of employees.
d) Experience and type of building and civil engineering works done (background).

Based on these criteria the firms were classified as follows:

<u>Level 1</u> – Teixeira Duarte SA (which based on accounting values, is the second biggest contractor in Portugal)

<u>Level 2</u> – Meliobra AS (which is a medium enterprise contractor)

<u>Level 3</u> – Construções Civis Bela e Moreira Lda. (which is a small closed family firm)

The waste stream was be recorded in the following ways:

A – The number and location of the case study.

B – The contractor that did the work and classification level.

C – The period of intervention.

D – Components recovered by dismantling.

E – Materials in the debris trail.

F – Photographic record of the building and works.

It was also necessary to record the presence of hazardous materials. The classification was chosen in order to facilitate the comparison of the results. The results are presented below:

Case Study nº 1

A – Case Study nº 1 – Location: Rua da Mouraria, 56 to 62, Lisbon. Building type: private dwelling house. Demolition process: hand demolition. Type of civil works: rehabilitation.

B – Contractor: Construções Civis Bela e Moreira Lta
Classification level 3

C – Period of intervention: 10 months

D – Components recovered by dismantling.
Roof tiles: 40 m3
Timber beams: 320 m3
Electric wire: 200 m

E – Material in the debris trail
Old plaster removed: 9 m3
Waste materials removed: 432 m3

The pilot study sample was used to estimate the composition by percentage of the waste materials. It was based on making comparisons with the same type of works undertaken from the same type of building. The results were:

. Other inert (soil, clay, lime, etc).........	92.7 %
. masonry...	5.0 %
. ceramic tiles......................................	0.4 %
. paper and cardboard..........................	0.1 %
. plastic...	0.1 %
. timber..	0.6 %
. metals..	1.1 %

F – Photograph of the site work: Plate 8.4.

Plate 8.4 – Photograph of the site works. Case Study nº 1

A contractor classified at level 3 developed the work related to this case study which lasted for a period of ten months. The response to the questionnaire reveals that this contractor demonstrated a strong awareness of environmental issues. The hard data results collected from rehabilitation works cannot be directly compared with the results from ADEME (1998) which were obtained from demolition activity. It is only possible to comment that there are enormous differences between percentages and composition of the waste trails.

Case Study nº 2

A – Case Study nº 2 – Location: Beco do Recolhimento, 2, 3 e 4 – Castelo de S. Jorge, Lisbon. Building type: private dwelling house. Demolition process: hand demolition. Type of civil works: rehabilitation.

B – Contractor: Meliobra SA

Classification level: 2

C – Period of intervention: 3 months

D – Components recovered by dismantling.

Timber beams 230 m3

E – Waste material removed: 362 m3

F – Photograph from the site work: Plate 8.5.

Plate 8.5 – Photograph of the site works. Case Study nº 2

A contractor classified as medium contractor developed the civil works for case study nº 2 in three months. The works were undertaken in an old house in conjunction with renovation works. The house was built in the last century. It was possible to strip out timber frames to a volume of 230 m3. Plaster, sand, stone and soil were removed and not separated. It amounted to a volume of 362 m3. Limited space on without space to install a container made any sorting of material impossible. The contractor expressed little interest in collaboration with the research project.

Case Study nº 3

A – Case Study nº 3 – Location: Beco do Forno, 2 – Castelo de S. Jorge, Lisbon. Building type: private dwelling house. Demolition process: hand demolition. Type of civil works: rehabilitation.

B – Contractor: Meliobra SA

Classification level: 2

C – Period of intervention: 3 months

D – Components recovered by dismantling.

Timber beams: 38 m3

E – Waste materials removed: 160 m3

F – Photograph from the site works: Plate 8.6.

Plate 8.6 – Photograph of the site works. Case Study nº 3

The case study nº 2 was similar to case study nº 3. The buildings had the same characteristics and were built in a similar period with an absence of space to sort material. The conditions of work on site were similar and the contractor was the same.

Case Study nº 4

A - Case Study nº 4 – Location: Beco do Forno, 18, lote 40, Castelo de S. Jorge, Lisbon. Type of building: private dwelling house. Demolition process: hand demolition. Type of civil works: rehabilitation.

B – Contractor: Meliobra SA

Classification level: 2

C – Period of intervention: 3 months

D – Components recovered by dismantling.

No components removed by dismantling

E – Materials in the debris trail

Waste materials removed: 716 m3

F – Photograph of the site works. Plate 8.7.

Plate 8.7 – Photograph of the site works. Case Study n° 4

The civil works of this case study were developed very closely with the works on case study n°3, which was in the same street. The same contractor undertook the work. The works were undertaken in a period of three months without any stripping out or consideration of the quality of the old materials. It was the oldest building in the study. Lack of space prevented the siting of different containers to allow sorting of the waste material. The biggest volume of waste material consisted of plaster, wood, sand, stones and soil was removed in the same container. The contractor was the same contractor as in case studies n° 2 and n° 3 and demonstrated a lack of interest in collaborating with the research team on this study.

<u>Case Study n° 5</u>

A – Case Study n° 5. Location: Rua Rodrigo Sampaio, 11, Diário de Notícias, Lisbon. Type of building. Office block: Demolition process: hand demolition.

Type of civil works: rehabilitation.

B – Contractor: Teixeira Duarte SA

Classification level: 1

C – Period of intervention: 2 months

D – Components recovered by dismantling.

Timber beams, doors, windows and other reusable components.

E – Materials in the debris trail

Waste materials removed: 770 m3 with separation on site as:

. Brick masonry................................ 46 %

. Stone masonry............................... 42 %

. Others inert.................................... 12 %

F – Photograph from the site work. Plate 8.8.

Plate 8.8 – Photograph from the site work. Case Study nº 5

The civil works related to this last case study were undertaken over a two months period, which was a time short for the size of project. The building was a concrete structure constructed in 1930 with very different site works to the other studies. The works were identified as interior renovation to change the use from residential to office. Timber beams, doors, windows and other components were reused on site in the renovation work. The contractor was neutral to the goals of the research team, but the site foreman showed great interest. This significant response meant that the work was organised to sort the materials in the limited available space. The sorting process was sufficiently rigorous to enable the reuse of components in the renovation works on site. The remaining waste was transferred to the only container and removed from site.

The Questionnaire developed by the working group

The objective of the questionnaire was to illuminate the attitude of the contractors to the issues at the core of the research project. It was also intended to explore the contractors' role in delivering on the goals of the project. This information was needed to gain a better understanding of the attitudes of the contractors. It would contribute to understanding the level of mismatch between the data collected and the data required. It would give insight into the difficulties in obtaining the data required and assist in preparing future programmes that would overcome the difficulties. A further objective of the questionnaire was to assist in the definition of qualitative variables in the dynamic model.

The questions were put to the 10 observers who worked with the contractors and recorded the site activities. There were five linked questions. Questions 1 and 2 concern the attitude of the contractor to the observers. Questions 3, 4 and 5 concerned the contractors' attitudes to environmental concerns and the goals of the project. The questions were answered using a Likert five-point scale classification, from "very positive" through "positive, neutral, negative," to " very negative", and attributing 1 to very negative and 5 to very positive. The questions were:

1) What is the attitude of the contractor to collaborating with the research project?

2) What is the attitude of the contractor to divulging information on the disposal of the waste?

3) What is the attitude of the contractor to environmental concerns?

4) What is the attitude of the contractor to reusing and recycling demolition waste?

5) What is the attitude of the contractor to changing behaviour to meet the goals of reuse and recycling?

Each observer answered each question with respect to each contractor, and the contractors were classified according to size.

1) A large contractor

2) A medium sized contractor

3) A small contractor

Table 8.9 shows the cumulative score recorded for each contractor for each question. The minimum possible individual cumulative score being is 10 and the maximum is 50

Table 8.9 – The cumulative score recorded for each contractor for each question.

	Contractor		
Questions	**1**	**2**	**3**
What is the attitude of the contractor to:	**Cumulative answer score**		
1 – collaborating with the research project?	29	32	42
2– divulging information on the disposal of the waste?	33	28	26
3 – environmental concerns?	27	33	28
4 – reusing and recycling demolition waste?	24	30	34
5 – changing behaviour to meet the goals of			
reuse and recycling?	27	27	31
Cumulative score for all questions	140	150	161

Figures in the middle third of the range from 10 to 50, that is approximately 24 to 36 would indicate a neutral position with respect to the question.

The large contractor would appear to be neutral with respect to all the questions. A borderline figure of 24, is recorded for question number 4. It suggests that the contractor tends towards a negative position with respect to reuse and recycling materials and components. This is surprising as the contractor was reusing components in the renovation works that were stripped out of the original building. This is clearly inconsistent. On closer examination, it was noted that the directors of the company were not very co-operative with the research project and would not talk to the observers. The actions of the foreman on site, however, were being interpreted as very supportive of the goals of the project. These actions may have been driven by environmental concerns or by commercial expediency. It is unlikely that the foreman would have acted unilaterally, so that the decision to reuse components was being made somewhere between the board of directors and the site management. It highlights that in a large organisation, there is a diversity of level where decisions are made that affect the final actions. Those decisions may be totally discrete from the aimed at goals.

The medium sized contractor would appear to be neutral with respect to all the issues addressed. This contractor, worked on three of the projects observed. In two of the projects, but not the third, timber beams were recovered for reuse. This suggests that actions, were being taken that were supportive of the goals of the project but for commercial expediency and not environmental reasons.

The cumulative scores recorded for the small contractor have a greater spread than the other two contractors. The highest score was obtained for question 1, the question relating to co-operation with the research project. The observers gained the impression that the enthusiasm may be driven more by commercial expediency than environmental concern. The opportunity to obtain more work from government and local authority sources is a powerful incentive to co-operate. The lowest score was recorded for divulging information on the disposal of the waste. Whilst it was in the neutral range it was close to a negative position. This could have been due to not knowing where the waste was disposed. This is unlikely as the directors of the company were actively working on site. A more plausible explanation would be that the disposal was to unlicensed landfill sites, and to divulge that information would jeopardise future work from the research programme. On the basis of the cumulative scores recorded, the large contractor was the most likely to divulge the destination of the waste and the small contractor the least likely. That information would tend to support the commonly held view that the large contractors are using licensed landfill sites, and are prepared to disclose the information whilst the small contractors are not on both counts.

Table 8.10 unpacks the questionnaire results further. Table 8.10 shows the number of answers recorded at each level, for each contractor, for all the questions.

This table demonstrates that the three contractors are, on the whole, neutral to the project, which confirms the position gained from the previous table. This table reveals a skew in the positions. The large contractor is shown to have tendency towards a negative position. The medium sized contractor is firmly placed in a neutral position and the small contractor is shown to have a positive skew.

Table 8.10 - The number of answers recorded at each level, for each contractor, for all the questions.

	Contractor			
Answer	**1**	**2**	**3**	**All**
1 very negative	0	1	1	2
2 negative	19	11	7	37
3 neutral	25	26	24	75
4 positive	6	11	16	33
5 very positive	0	1	2	3
Total number of answers	50	50	50	150

The figures on which table 8.10 are based are shown in Table 8.11.

The base figures generally confirm the deductions from the aggregated figures. The small contractor scored consistently positive for co-operation, but no contractor was consistently recorded as scoring a negative response. The small contractor was perceived to be very negative, by observer 10, to divulging information on the disposal of waste. All the other scores for contractor 3 from that observer were positive, and the contractor was clearly seen as the most positive by that observer. The only other "very negative" observation, was for contractor 2 from observer 7 on question 5, the one concerning behavioural change. Observer 7, awarded a "very positive" to contractor 3 for the question on co-operation, question 1, as did observer 4 they were in line with the other observers as has been noted. Observer 3, was the only observer who was unable to differentiate between the contractors. Observer 8, was alone in reversing the order of the contractors with respect to the overall positive response to the project considering the large contractor the most positive.

Table 8.11 – The base scoring by observer, question and contractor.

Contractor	1						2						3					
Question	1	2	3	4	5	all	1	2	3	4	5	all	1	2	3	4	5	all
Observer																		
1	2	4	3	3	3	15	3	4	3	3	4	17	4	3	3	3	4	17
2	3	3	2	2	2	12	4	3	3	3	4	17	4	3	3	4	3	17
3	3	3	3	2	3	14	3	3	2	3	3	14	4	3	2	3	2	14
4	4	3	2	3	2	14	4	2	3	4	2	15	5	2	3	3	3	16
5	3	4	3	2	3	15	3	2	3	3	3	14	4	3	2	4	4	17
6	2	3	2	2	4	13	4	3	4	2	2	15	4	3	3	3	3	16
7	3	2	3	2	3	13	2	2	3	3	1	11	5	2	3	4	2	16
8	4	3	4	3	3	17	4	3	5	4	2	16	4	3	2	3	3	15
9	3	3	3	2	2	13	3	3	4	3	3	16	4	3	3	3	3	16
10	2	2	2	3	2	11	2	3	3	2	3	13	4	1	4	4	4	17
Table 8.9	29	33	27	24	27		32	28	33	30	27		42	26	28	34	31	

The figures in Table 8.9 are obtained by adding up the figures in the appropriate columns of Table 8.11.

The Interpreting and Treatment of Data

In summary, the results from Lisbon multiple case studies are weak in terms of "hard" data collection. The "soft" data has revealed differences between the contractors which may, or may not , be reflected in the industry as a whole. If those differences were to be reflected across the industry it would enable different approaches, based on contractor size, to be made to disseminate information on this issue. It is clear that commercial expediency has driven some decisions that are very positive. The clearly demonstrates the necessity to adopt qualitative variables in the model construction.

All the data collected was from renovation works. It was demonstrated that there were significant environmental constraints, relating to insufficient space on site, on realising the potential for reuse and recycling. It was noted, however, that where the contractor perceived a benefit ingenuity overcame the restraint. The results from the case studies 1,2,3 and 4 were compatible with the pilot study but different from the results from case study 5. Case study 5 was a different type of building but this is not sufficient to explain the differences. The case studies did not give accurate information in terms of the composition of the waste material, due the impossibility of sorting the materials removed.

These results and experience must be compared with the results from the study from ADEME (1998). This must be noted that the ADEME study is from an area of France, that has many common characteristics in the building and construction sector with Portugal. The results from the ADEME survey were used to conceptualise and structure the dynamic model, which was then adapted to the Portuguese strategy, goals and targets. The results of the multi case studies, demonstrate the quantity of work that must be undertaken to improve the Portuguese performance in this area of study. The priority must be to manage the waste stream with the involvement of all actors.

SUMMARY

In this Chapter a global overview was taken of the Portuguese experience and knowledge in the construction and demolition waste stream. The waste management policy in the country that is developing under EU guidelines and legislation was also observed together with its relationship with the construction industry. The evaluation of the types of civil construction in the Lisbon area was also placed in a national context. The state of the art of construction and demolition waste stream in Portugal was considered. Estimates of the production of waste were made and the feasibility of developing a Lisbon recycling plant considered. The Lisbon area case studies were described and characterised. The difficulties in initiating the studies of the waste stream were also analysed. This was based on the fieldwork experience collecting hard data and from the soft data concerning the resistance to change and behaviour towards sustainable practices.

The data collected in the Lisbon case studies and the results from the survey developed by Lobbe Derconsa SA (1997) were added to the results from the six reported case studies. They will, with the results from the ADEME (1998), contribute to the definition and development of the dynamic model.

CHAPTER 9:

THE DECONSTRUCTION PROCESS TOWARDS A DYNAMIC MODEL

"Give me a firm place to stand and I will move the earth"

(Archimedes 287 – 212 B.C.)

INTRODUCTION

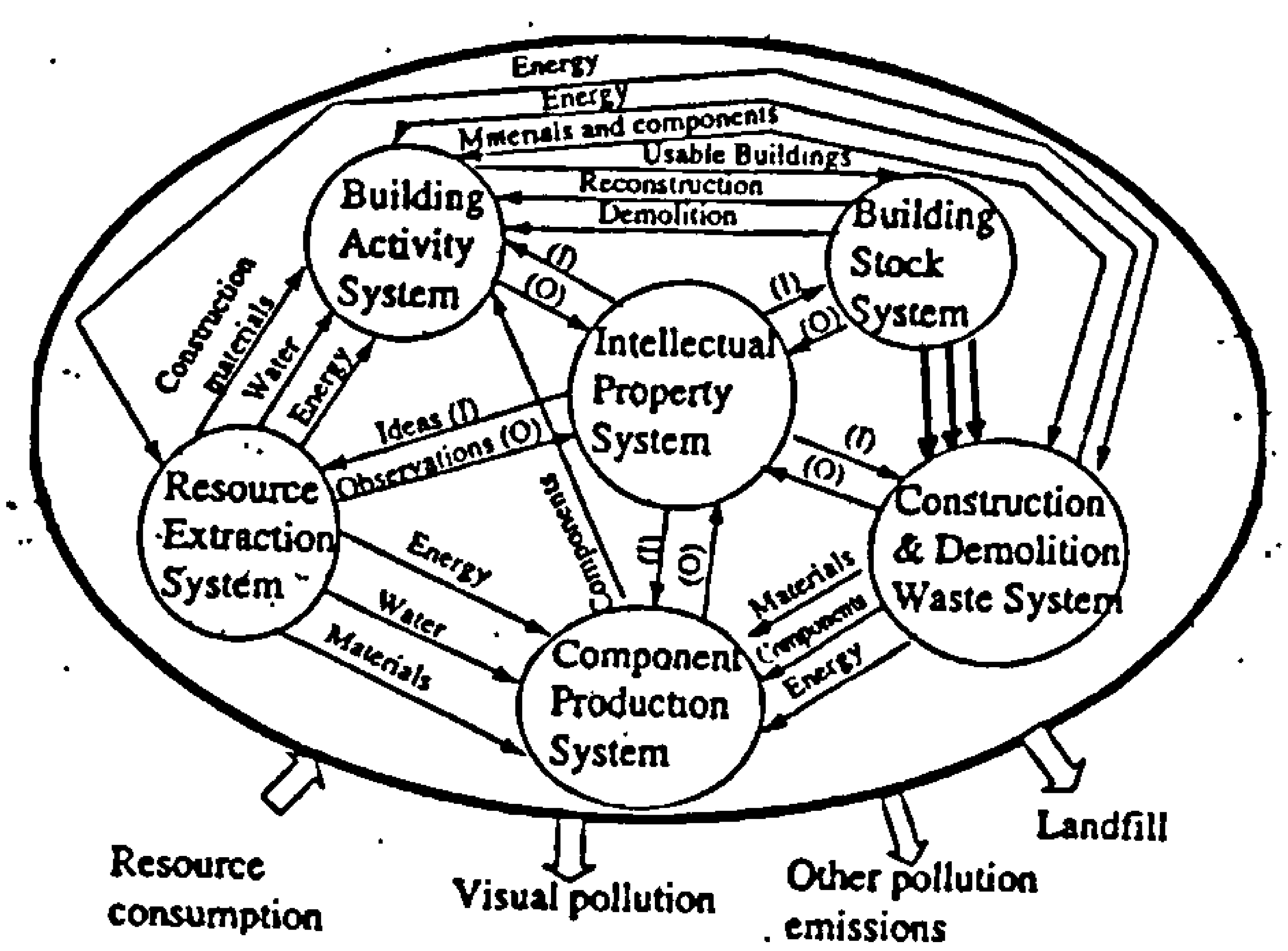
This Chapter discusses the deconstruction process and its characteristics leading towards the construction of a dynamic model. The model will be a tool to estimate quantities and composition of the construction and demolition waste stream. The model was constructed after developing the Lisbon area multiple case studies, a survey and the questionnaire discussed in Chapter 8. Knowledge from international case studies, reported and presented in Chapter 7, was also used together with that from the French experience in this area dating from 1990 (ADEME 1998), which is discussed in depth in this Chapter. References to other international experiences and knowledge are presented in Appendix I. Soft system methodologies and system dynamics are used, as well as dynamic software. Section 1 is focused on building and construction environmental impact system. It is unpacked, discussed and re-packed to understand how it contributes to knowledge of the waste stream. Section 2 is focused on system dynamics and its contribution to the definition and construction of the dynamic model. The use of Powersim software is also discussed. This software makes it possible to develop different scenarios with dynamic model simulation. Section 3 is about the development and scenarios of the dynamic model. It discusses the application of the model to the waste stream. It also illuminates the new Portuguese strategy in solid waste management in this particular waste stream.

SECTION 1: THE BUILDING + CONSTRUCTION ENVIRONMENTAL IMPACT SYSTEM

The conceptual and dynamic model (Inácio and Golton 1997) developed in the course of this research was presented at the 1997 Bizarre Fruit Conference held at Salford University in November 1997. The model represents the global building and construction environmental impact system. The boundary of the system encloses six integrated and interactive sub-systems, where there are two kind of activities. "Real world activities" involving people in the problem situation and "Systems thinking" activities which may or not may involve those in a problem situation. These concepts and the global model were described on Chapter 1, Figure 1.7. Figure 9.1 presents the

The six sub-systems have interactive quantitative and qualitative inputs and outputs within the global system. The exception is the qualitative sub system or perspective of the intellectual property system. That sub-system qualitatively drives all the other sub-systems making observations and emitting ideas. The study focuses on the construction and demolition sub-system and its outputs in terms of materials, components and energy and its inputs and outputs to the other sub-systems. These characteristics are fundamental to understanding, conceptualising and defining the dynamic model of the management of the waste stream.

Figure 9.1 – Building + Construction Environmental Impact Systems



Source: Inácio and Golton 1997:106

In order to move towards sustainable construction it is necessary to estimate and evaluate the contents of the construction and demolition debris trail. The study has investigated human participation and dimension illuminating the "soft" characteristics of the deconstruction process. The actor's role and methods used are also critical in understanding and constructing the dynamic model.

Unpacking the Construction and Demolition
Waste Stream Sub-System

This sub-system has three quantitative interactions with three other sub-systems. All of them are inside the global building and construction environmental impact system. Those interactions are:

- Energy flows from the Resources Extraction Sub-System, to the Construction and Demolition Sub-System.

- Energy, flows from the Construction and Demolition Sub-System, and receives materials and components for the Building Activity System.

- Materials flow with components and energy, from the Construction and Demolition Sub-System to the Component Production System.

From a qualitative point of view:

- Observations flow from the Construction and Demolition Sub-System as well as ideas from the Intellectual Property System, the Sub-System that drives all the Sub-Systems. Intellectual Property Sub-System provides the qualitative overview that supports the option, to use a qualitative methodology soft system and system thinking.

The nature of the deconstruction process was studied illuminating the factors that could create difficulties for the minimisation of resource loss and energy consumed. This was studied in terms of physical and mental constraints, that could affect the efficacy of the process and final results. The first priority of the deconstruction process was the safe removal of hazardous materials. The first phase of the deconstruction process was the dismantling phase, consisting of those components such as roof tiles, windows, doors, sanitary units and electrical components. It included all those components that could be stripped out in good condition, for sale on the second-hand market for reuse. The second phase of the deconstruction is selective demolition. The materials from these works, such as brick masonry, stone masonry, cement, plaster, concrete, ceramics, timber, metals, plastics, carpets need to be separated.

These fundamental characteristics of the construction and demolition system will be included in the concept of the dynamic model. To illuminate and improve the dynamic inter activity a soft system overview, will be fundamental to define and forecast the "real world" scenarios.

SECTION 2: SYSTEM DYNAMICS TOWARDS A DYNAMIC MODEL CONSTRUCTION

Principles and guidelines to dynamic model development

The pioneering works on system dynamics at the Massachusetts Institute of Technology, School of Industrial Management was undertaken in 1956 by Forrester (1961). He held the basic patent for magnetic core memory but decided to put aside his electro-mechanical research and apply the principles of feedback control to socio-economic systems. This was the beginning of systems dynamics. The objective of system dynamics is the promotion of the rigorous study of systems and their behaviour using the principles of feedback, dynamics and simulation. In his studies Forrester (1968) demonstrated that the human environment is highly complex and dynamic.

The first study applied these principles to the problems of managing a corporation and resulted in the publication of Industrial Dynamics (Forrester 1961). It was a comprehensive treatment of the use of feedback principals and simulation to aid the management of a company. The steps of a system dynamics analysis were described in the book "Industrial Dynamics" (Forrester 1961) with a sequence as follows:

- Identify a problem.
- Isolate the factors that appear to interact to create the observed symptoms.
- Trace the cause and effect information feedback loops that link decision to action resulting in information changes to new decisions.
- Formulate acceptable formal decision policies that describe how decisions result from the available information streams.
- Construct a mathematical model of the decision policies, information sources, and interactions of system components.
- Generate the behaviour through time of the system as described by the model (usually with a digital computer to execute the lengthy calculations).
- Compare results against all pertinent available knowledge about the actual system.
- Revise the model until it is acceptable as a representation of the actual system.
- Redesigning within the model, the organisation relationships and policies that can be altered in the actual system to find the changes that improve system behaviour.

- Alter the real system in the direction that the model experimentation has shown will lead to improved performance.

Some years later, Forrester (1968) completed this understanding of the systems principles as the structure of knowledge. Over the past three decades, system dynamics have been applied broadly in areas such as environmental changes, economic development, social unrest, urban decay, psychology and physiology. There has been a corresponding growth in the base tools being developed and applied including things such as causal loop diagramming, chaos theory, statistical analysis and interactive learning environments (Forrester 1980).

Though eclectic in content and methods, system dynamics retains certain underlying principles that form an important bridge between reality, and our ability to understand how our world is growing ever more complex. These principles could be highlighted as:

- Concentration on dynamics and feedback relationships.

- Representation of decision-making behaviour based on actual information availability.

- Explicit recognition of disequilibrium and the process adjustment.

- Incorporation of non-linear relationships when appropriate.

- Quantification of unmeasured but important concepts and relationships.

Maintaining these principles, and the work developed in system dynamics is both understandable and relevant. It is a method for studying the world around us. The central concept to system dynamics understands how all the objects in a system interact with another. System dynamics looks at things as a whole? This is in contrast to the reductionist scientific approach, where the world is studied by observing it in smaller and smaller discrete pieces, The objects and people in a system interact through feedback loops, where a change in one variable, affects other variables over time, which in turn affects the original variable and so on. This is the primary approach and essence of systems dynamics methodology. It enables an understanding of how human beings live in a complex, dynamic reality of natural and social systems. Most systems are not in equilibrium and their states are changing continuously. To understand, adapt and to control this reality requires the capture of the characteristics in formal models. It is necessary to use computers and simulation models to simulate and to investigate the relationship between the structure and the behaviour of systems dynamics. They can process the variety and complexity of most of the systems experiencing problems.

A simulation model can be looked upon as creating a virtual world. This realism does not imply the optimal solution, in many cases that cannot be found. The simulation can only provide realistic solutions that can be implemented in practice. As Davidson (1996) says quoting a wise person:

"It is better to be almost right than exactly wrong".

These complex systems have an understandable link with human intuition, and in this sense there are four kinds of structural properties that humans find cognitively challenging in dynamic systems (Davidson 1996). They are as follows:

" 1 – There is the origin of dynamic behaviour itself – The relationship between flows and levels. Levels accumulate flows, and flows cause the levels of levels, to change over time. Although simple in principle, humans often find it difficult to distinguish between real levels and flows and to identify the behavioural consequences of flows acting on levels.

2 – There are delays or lags in the actual system. Delays distribute the effects of changes in variables throughout a system over time, and often cause information to arrive at its destination in a untimely, at hence harmful manner. Delays and lags lead humans to discover and give priority to short-run gains, and to ignore and postpone

actions against future losses. Delayed reactions, typically cause systems to over and undershoot and thus to exhibit oscillatory behaviour.

3 – There is feedback. "Real world" systems are characterised by circular causality. Their structures contain feedback loops that transmit the dynamic behaviour of one attribute to the next until the circle is closed and the signal, in a modified form, is fed back to its origin. Such loops have the tendency to stabilise or to destabilise a system. Humans then try to manage a feedback system, their actions are typically amplified or counteracted, depending on which feedback structure are dominating the system at the time.

4 – There is non-linearity. Non linearity implies that systems attribute influence to each other in a non-proportional way, and they interact so that partial effects playing out over time cannot easily be distinguished. Such interaction may cause shifts in the structural dominance of a system over time. That is substructures that have dominated a system behaviour for some time, may suddenly or gradually, lose their influence while other substructures gain influence."

The software characteristics

The original system dynamics software was Dynamo for use on IBM PC computers. Sometime after came Dysmac2 (Dangerfield and Vapenikova 1987). It used a similar equation format to professional Dynamo and again was specifically designed for used on IBM PC computers. Both programs facilitate rigorous development of large models. In addition, other system dynamics software models were developed in recent years for Apple Macintosh computers, the most notable of which is Stella (Richmond, Vesunoz and Peterson 1987).

In Stella the pipe diagrams representing models, can be drawn directly on the computer screen using a predefinition tool kit. Icons can be opened to insert parameter values and relationships between variables represent the variables of the diagrams. Stella software is a particularly useful and appealing language for fast model building by those users who are less familiar with computing programming. Powersim is a simple to use updated software alternative and a powerful tool to model construction (Cover 1996).

The systems dynamics methodology can contribute to the understanding of complex problems as they allow the development of intuitive and simple models. The characteristics are:

- The dynamic nature and the complex relationship between the regulator entities, enterprises, markets and the environment and to model the interactions, feedback and delays between economic and ecological variables on different time frames.

- The integrated environmental effects during a product life cycle. It is important to model the accumulated environmental consequences of a product manufacturing process simultaneously with the different phases of the process.

- The economic system functioning as a result of the economic agent transactions based in goods and services and supported by a biophysical system. In this situation the energy and/or the mass flows are associated with the market transactions.

These parameters are essential to developing an approach to the environmental economic relationship between environmental policy, market goods, resource utilisation, emission and environmental quality. It also facilitates an integrated approach to the analysis of the different effects that a product has on the environment during the different phases of life cycle.

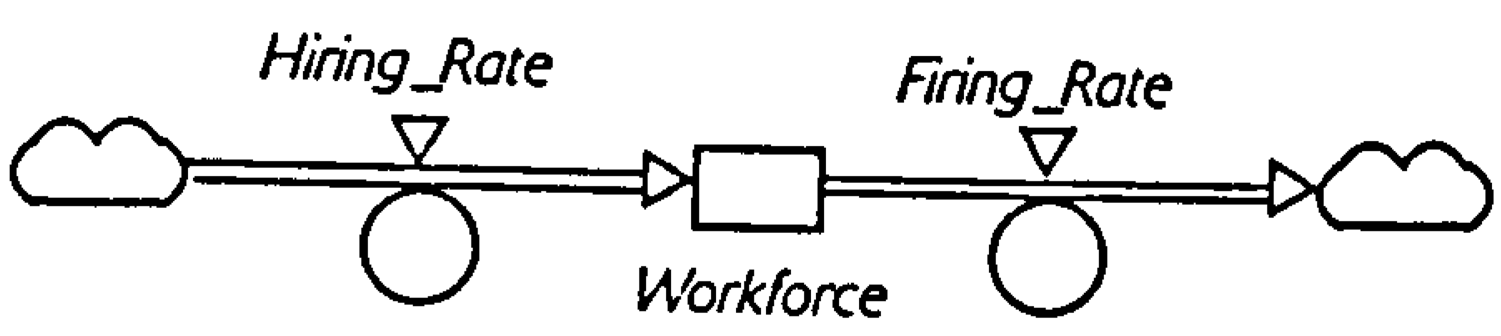
The software tools facilitate and contribute to the systems dynamics study. The attempt to develop these dynamic models and reflect reality with their complexity has given rise to two implications (Cover 1996):

- The model must reflect the complexity of the real system. Even though simplicity is a virtue, complexity is often a necessity.

- The optimal solutions must be based on the simulation techniques and also on the experimental identification of the real solutions.

This complexity is a challenge to human intuition. In particular, there are structural properties that challenge the cognitive capacities, system behaviour sources and the relationship between flows and stocks (see Figure 9.2). Stocks have a flow that results in the change of stock volume over time. Simplicity is fundamental but difficulties often occur in distinguishing real stocks and flows and identifying the interaction between the flow and its consequences in terms of stock levels.

Figure 9.2 – Flow and Stock representation on System Dynamics software



Source: Cover 1996:28.

System dynamics has the capacity to facilitate the construction of micro systems, which permit the study of the behaviour of a complex mechanism. This strength is apparent when these microstructures are integrated and interact together with common objectives. The ability to step through the process is an iterative process and is a fundamental tool in the solution of real problems.

The designer of the software modelling system needs to define the problem. Understanding the problem behaviour is essential in order to create the model structure. It is necessary that not only the behaviour of the individual variables are considered but also the way each variable interacts with other variables to produce the system behaviour. Model formalisation and model simulation are the last steps of systems dynamics modelling. It is important for the designer to develop a mental model before creating the dynamic simulation model. It is common for computer simulation to display three characteristics as follows (Cover 1996):

1 - Time horizon, that is the total period of time for which the simulation is required.

2 - Time step, which is the interval of time between each software calculation.

3 - Integration models are commonly based on the Euler or Runge Kutta methods although there are other integration methods available.

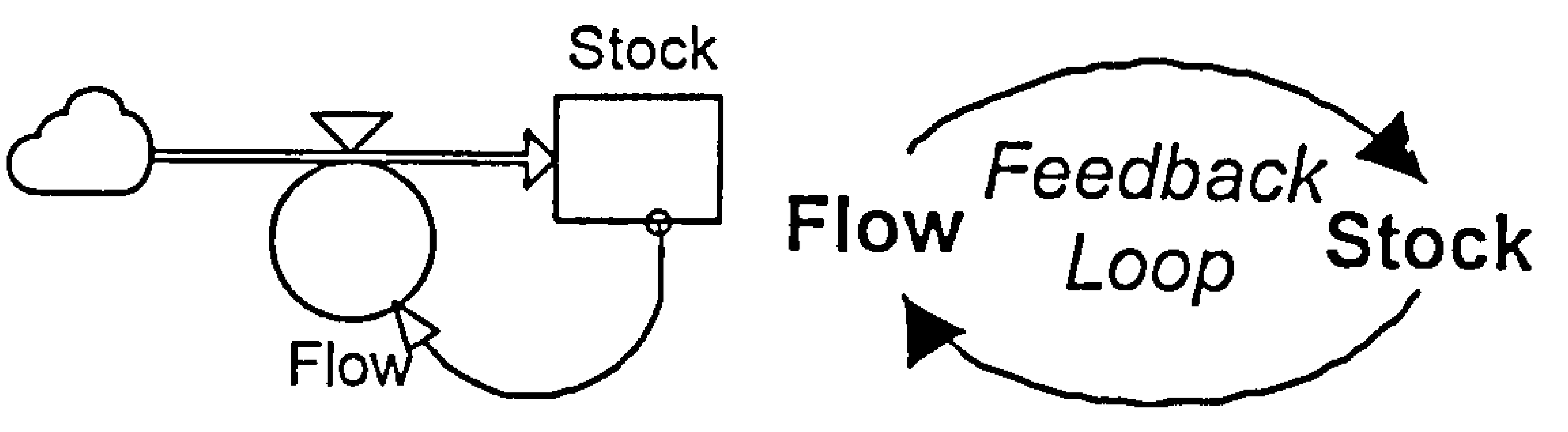
At present the following integration methods are available to simulation model designers (Behrens and Sorensen 1980):

- Euler
- Runge – Kutta
- Trapex
- Gear Predictor – Corrector

This list is changing due to the appearance of new methods and new versions of known methods. Through the use of the comparative plot facility it should be possible for the software designer to get an idea of which method is best suited for the particular problem. Furthermore, it should be possible for the software designer to incorporate his or her own integration routines, provided certain input requirements are met. These routines need to be written in an appropriate scientific programming facility (Behrens and Sorensen 1980:161). The strengths and weakness need to be considered in the context of the requirements of the system dynamics model. Those requirements are frequent output, moderate accuracy, and occasional mild stiffness. The Euler's integration method out-performs others in this environment, but requires the user to choose the step size. To overcome this necessity, a low-order Runge-Kutta method with variable step size is recommended (Pugh 1980:179).

System's levels and flows are imbedded in feedback loops. Feedback is the transmission and return of information. In systems dynamics modelling, information about a system's levels travels throughout its structure until it reaches its flows. In response to the information, the flows alter the levels and hence close the feedback loops, as shown in Figure 9.3.

Figure 9.3 – Flow, Levels and Feedback Loops in System Dynamics



Source: Powersim 2.5 1996a:191.

Positive and negative feedback loops exist in system dynamics modelling. Positive loops generate self-reinforced behaviour and negative loops generate stabilisation or counteracting behaviour. Another basic idea is that in a system dynamics model the feedback loops are often joined together by non-linear couplings. Essentially this means that information about a system's levels feed back and affect the levels in non-proportional and often complicated and unpredictable ways.

A further idea is that the dynamic behaviour inherent in a system's dynamic interacting levels, flows, feedback loops, and non-linear couplings, cannot be discovered by the unaided human mind, nor solved mathematically in a closed form. Computer simulation is required to reveal the dynamic behaviour of complex systems.

Model definition and software construction

According to Wilson (1984), the model definition could be "... the explicit interpretation of ones understanding of a situation, or merely of one's ideas about the situation. It can be expressed in mathematics, symbols or words, but it is essentially a description of entities, processes or attributes and the relationships between them. It may be prescriptive or illustrative, but above all, it must be useful."

The model could be classified into iconic, analogic and analytic models. Iconic models are usually based on a change of scale but not always. This means that the model is normally a miniature or enlarged version of the real article and relevant properties of the real article are represented by the properties themselves. Thus the replica is usually constructed with a degree of confidence, and it will be expected to reproduce the behaviour of the original. For example, a pilot plant for a new recycling plant or a stress model of a bridge or an aircraft model for wind tunnel testing. There are many examples like these ones all based on modelling the physically characteristics of the real object.

The analogic model is a model of quite different physical appearance to that which is being modelled. It may be constructed and expected to reproduce representative behaviour. For example water flow through small plastic tanks at room temperature is used to investigate the behaviour of molten glass furnaces at temperatures around 1000 ° C. An electronic network can be used to represent the flow of water through pipes or the flow of heat between surfaces.

Analytic models, are related with mathematical or logical relationship, and can be developed to represent the laws, which it is believed govern the behaviour of the situation under investigation. Such development will usually precede an analogue model.

Conceptual modelling is a further category. It may precede any of the other kinds of modelling to inform the construction of the following model. All the model forms have their own strengths and weaknesses and the choice of the most appropriate modelling technique is based on the match of those characteristics to those required to be modelled (Wilson 1984). This research into construction and demolition waste streams is best modelled by the use of conceptual and analytic models.

The logical sequence is illuminated by soft systems methodology, where the first steps reveal the relationships and the final steps reveal the actions in the "real world". This approach has middle steps that reveal the systems. The resolution of an activity model is based on the root definition. The root definition is the core purpose of the purposeful activity system and it assists in establishing the hierarchy in "real world".

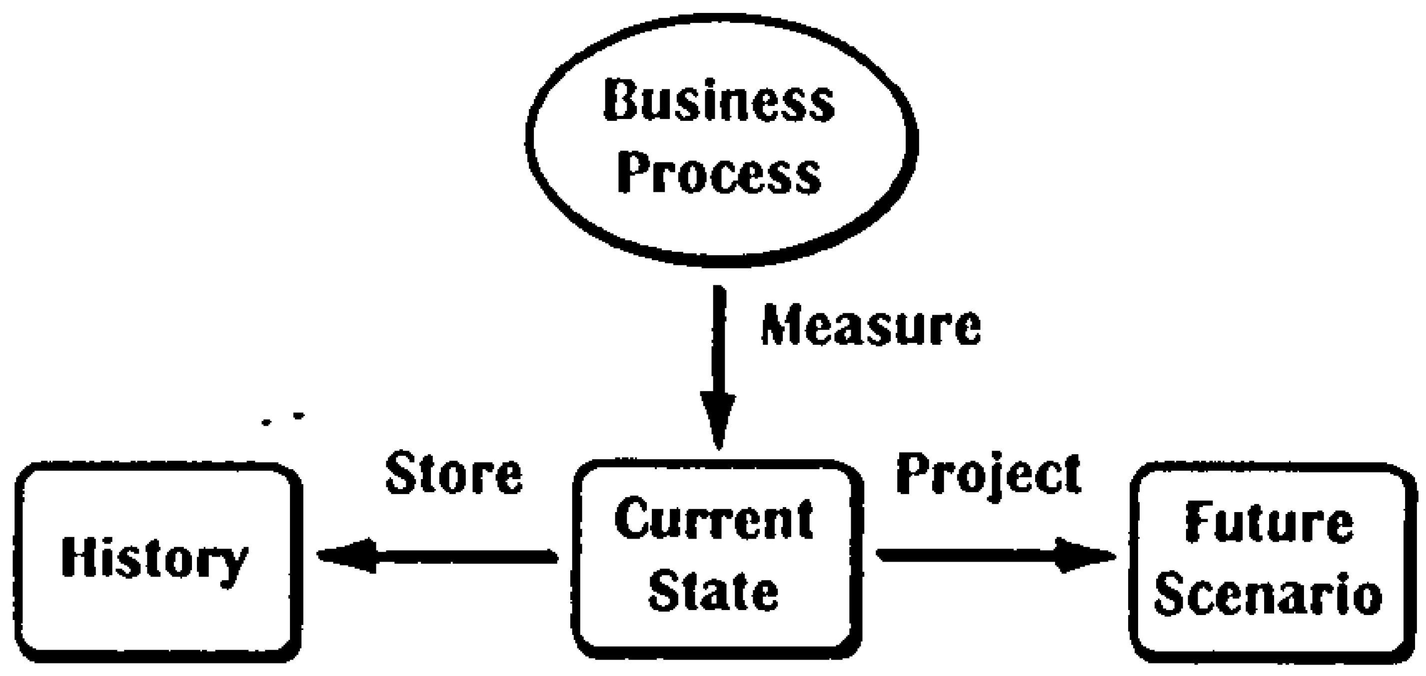
Problem definition begins with defining the problem that it is the intention to model. It is the keystone of the entire activity. The first step is to conceptualise the model as a prelude to formalising the model. It is necessary to have a clear idea and a mental structure of the concept to conceptualise the model. A cognitive mind map can help and can be the basis for producing a quantitative model (Eden, Jones and Sims 1983). According Eden, Jones and Sims (1983) this is easy to convert into an influence diagram for system dynamics modelling.

The researcher's qualitative interpretation will be embedded in the model. As Forrester (1980) points out, everyone uses mental models everyday. The mind does not contain real economic or social systems. Instead they contain representations, models of reality. These models are used in all aspects of decision making as they shed light on the context of an organisation (Cover 1996).

The mind's internal exploration is essential in order to know the real capacities of our brain. There are techniques that can improve the real capacities of the brain (Buzan 1995). The mind is able to define problems in ways that allow them to structure fieldwork. The brain has to structure the information in such a way as to slot in as efficiently and easily as possible.

In making models of the "real world", or in a "real world" process, the need to transfer data between model and external files, applications or other devices become important. A variety of tools are used in describing, measuring, storing, retrieving, transferring, analysing and presenting, in this case, waste management construction and demolition data. This is shown in Figure 9.4.

Figure 9.4 – Past, current and projected waste management construction and demolition data



Source: Powersim 2.3 1996b:197.

Databases and spreadsheets are commonly used to store current and past business data. Statistics can be produced based on time series (history) of data. System behaviour can be described using time graphs and time tables that may be produced easily using a variety of tools, including word processors, presentation software, spreadsheets, and data base front-ends. System structure (relationships, cause and effect) is often described as static maps (organisation charts, flow charts, etc.). For simple systems, system structure infers system behaviour. Using statistical methods (models) projections may be made into the future, for example by extrapolation. Even within the field of systems thinking a variety of tools are used.

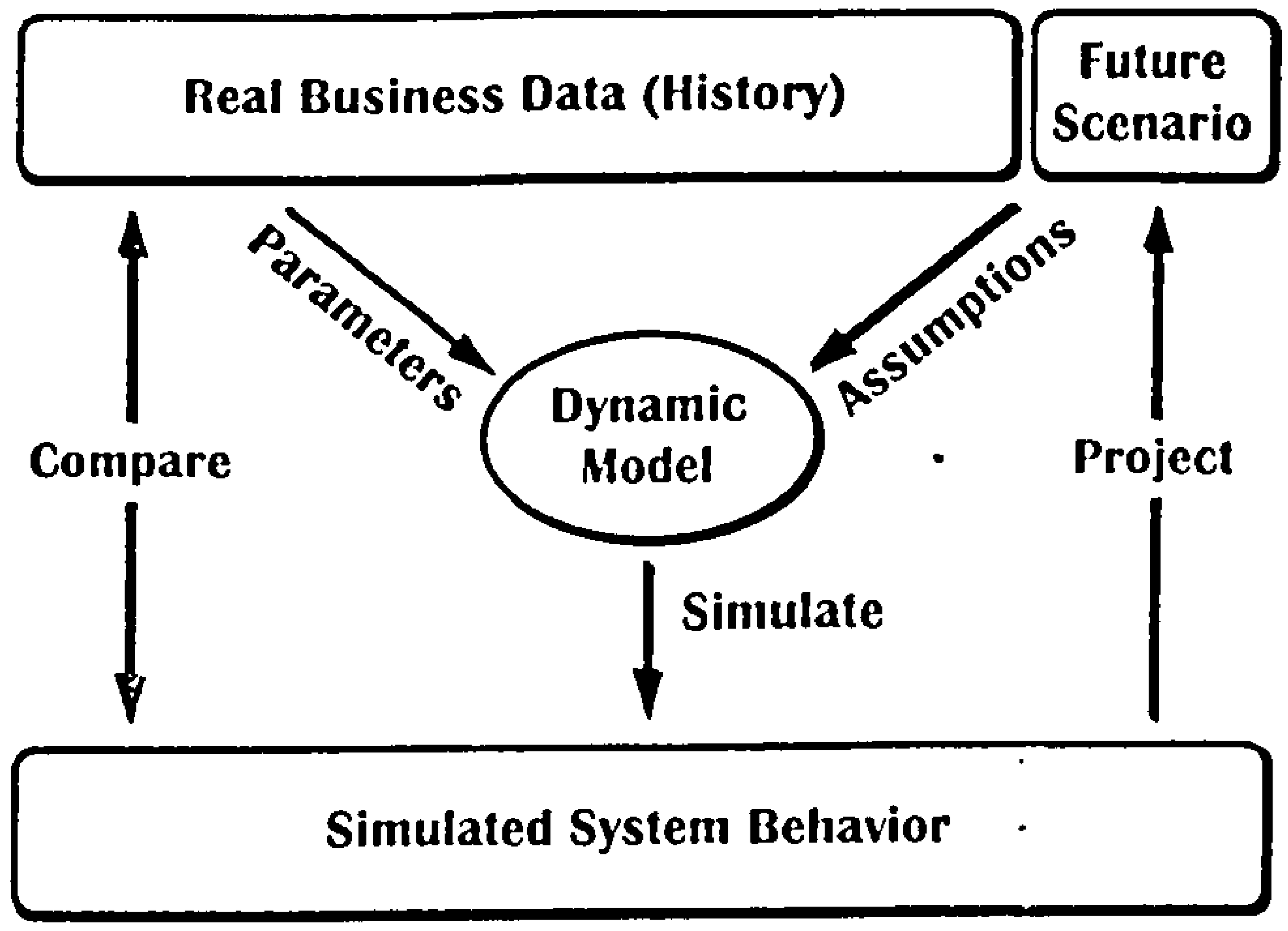
Simulation

Simulation of system dynamics models can be carried out in any computer language. Clearly high-level computer languages are appropriate. The use of purpose built software programmes are better since they can encompass algorithms that facilitate the construction of dynamic models (Wolstenholme 1990). For example they contain sort routines to place simulation equations into a computable sequence, and include a host of functions, to assist with the formulation of specific model relationships and policy.

System dynamics has been applied to a wide variety of issues and problems in public and private sectors. Forrester (1980) has been advocating the use of systems dynamics applications to management and to the education sciences. An example of this is the Road Map, a "do it yourself" process to learn about systems dynamics. Systems Dynamics for Kids (MIT 1996) is also a useful reference. These Road Maps begin as a project titled "The Systems Dynamics in Education Project" which was established in the Massachusetts Institute of Technology in 1990 (MIT 1991). They were used in urban studies and environmental sciences. The Meadows team in the field of environmental sciences (Meadows, Meadows and Randers 1996) demonstrated dynamic simulation. The EASY5 dynamic software, developed by the Boeing Company (Boeing 1997) applied the process to the management of flight simulation.

The dynamic model simulation is a virtual view of the real world and databases, spreadsheets, statistics, specific software and other tools can be used to feed, improve, and support the model. Figure 9.5 displays an idea about transferring data to and from a simulation in a dynamic model.

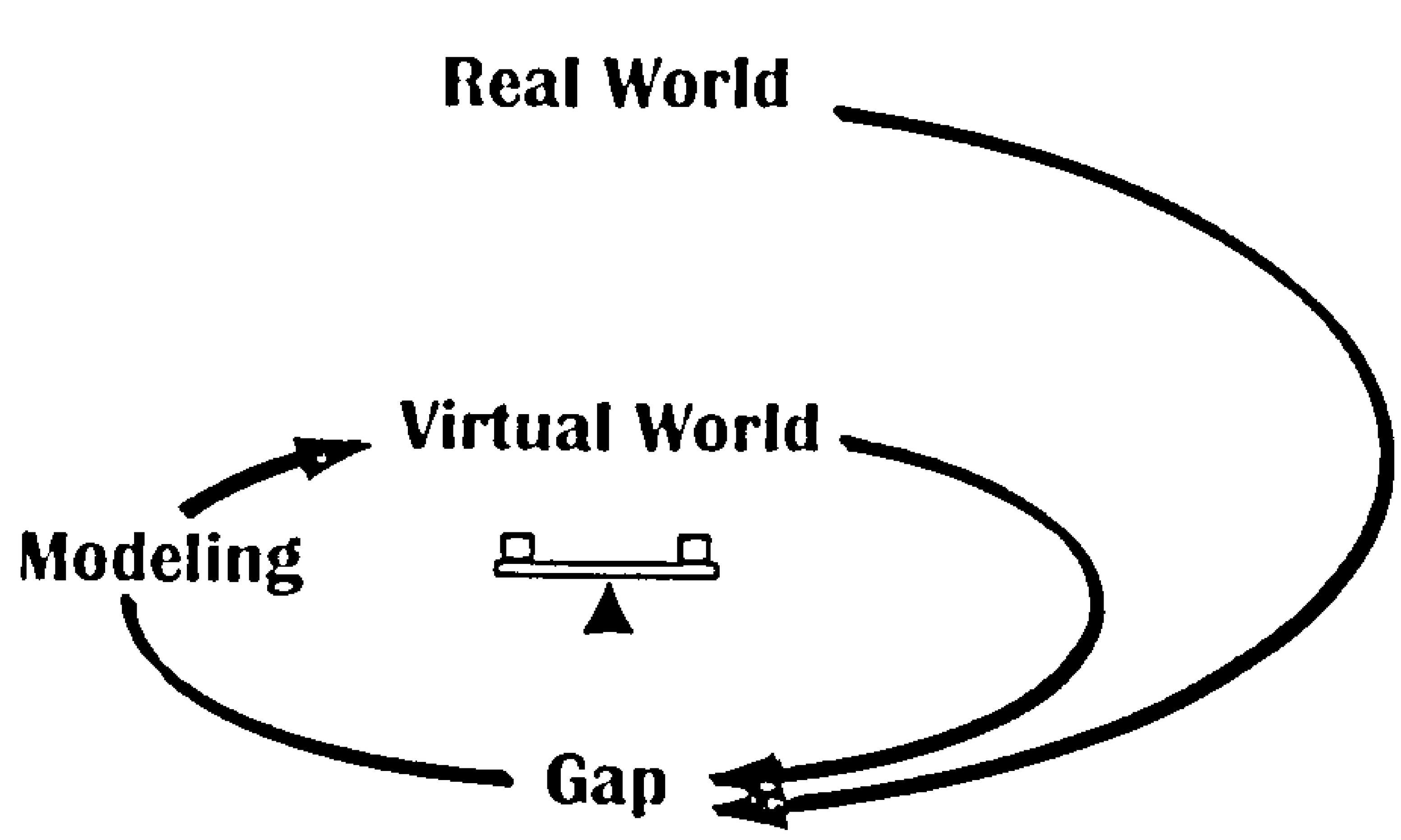
Figure 9.5 – Transfer of data to and from simulation in a dynamic model



Source: Powersim 2.5 1996b:198.

A simulation model can be compared to a hypothesis about a phenomenon. By comparing model behaviour to the real world it possible to determine the validity of any hypothesis. A dynamic model that corresponds well to the phenomenon it describes can be used to develop theory. It is also important to examine over time the gap between the virtual world derived from modelling and the real world derived from experience and nature. This is undertaken by comparing simulation outputs, with the real world measures. Figure 9.6 presents these guidelines with a balancing feedback loop on the virtual word circuit.

Figure 9.6 – Comparing simulation output to real world measurements



Source: Powersim 2.5 1996b:200.

Simulation models can be used in the investigation of the relationship between the structure and the behaviour of the dynamic system. This should show how the imbalances occur and how the structure could be changed to minimise their effects.

The Dynamic Construction and Demolition Model

The conceptualisation and development of a dynamic construction and demolition model will be required to simulate strategy scenarios to develop a policy for this particular waste stream. The model will contribute to knowledge from a qualitative and quantitative perspective. It will contribute to the identification of areas where knowledge is lacking and so indicate where further research is required.

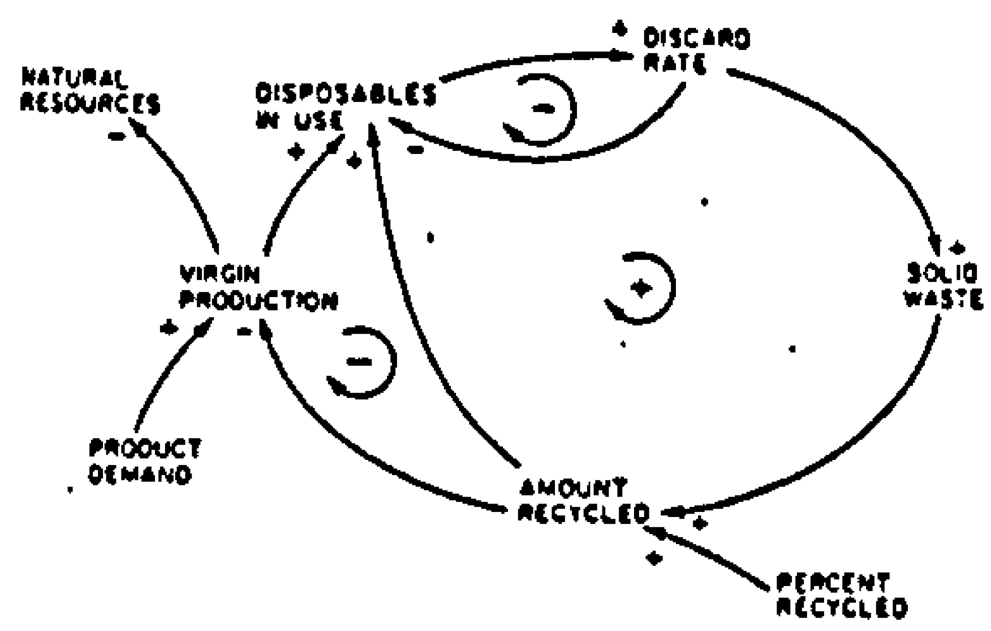
The building of a conceptual model is based on principles that have been tested in many studies carried out over several years Checkland (1991). A model of a human activity system will contain a set of activities with a minimum number necessary for the system to be connected together and concisely as described in a "root definition". This "root definition" is a concise brief description of a human activity system, which states what the system is and what it does. The conceptual model is then elaborated and built on the basis of the definition. Every element in the definition must be reflected in the model derived from it.

A well formulated "root definition" will make each of the CATWOE, referred to in Chapter 6, elements explicit. To sum up, the "root definition" describes a notional system chosen for its relevance to what the investigator and/or the people in the problem situation perceive as matters of contention. These will need to be connected together, in order to represent the system as an entity. The simplest form of connection is a number of arrows, which indicate logical dependencies (Checkland and Scholes 1990).

It seemed essential, in this research, to represent a flow whether it was of materials, components, energy, observations or ideas. The aim was to build an activity model of what must go on in the system. An example was the Construction and Demolition Sub-System, where developing the conceptual model consisted of assembling the list of activities or verbs describing the activities required by the "root definition". They were subsequently connected according to the requirements of logic and indicated any flows that appear essential at its first level resolution.

Roberts et al. (1982:189) studied the dilemma of solid wastes management and disposal from a dynamic view on the basis of the dynamics of change. Change arises from growth, decay and fluctuation. Roberts et al. (1982), presented a causal loop diagram which represented a system that encouraged homeowners to sort their own wastes at home. Figure 9.7 shows this model where materials flows in production and recycling are highlighted.

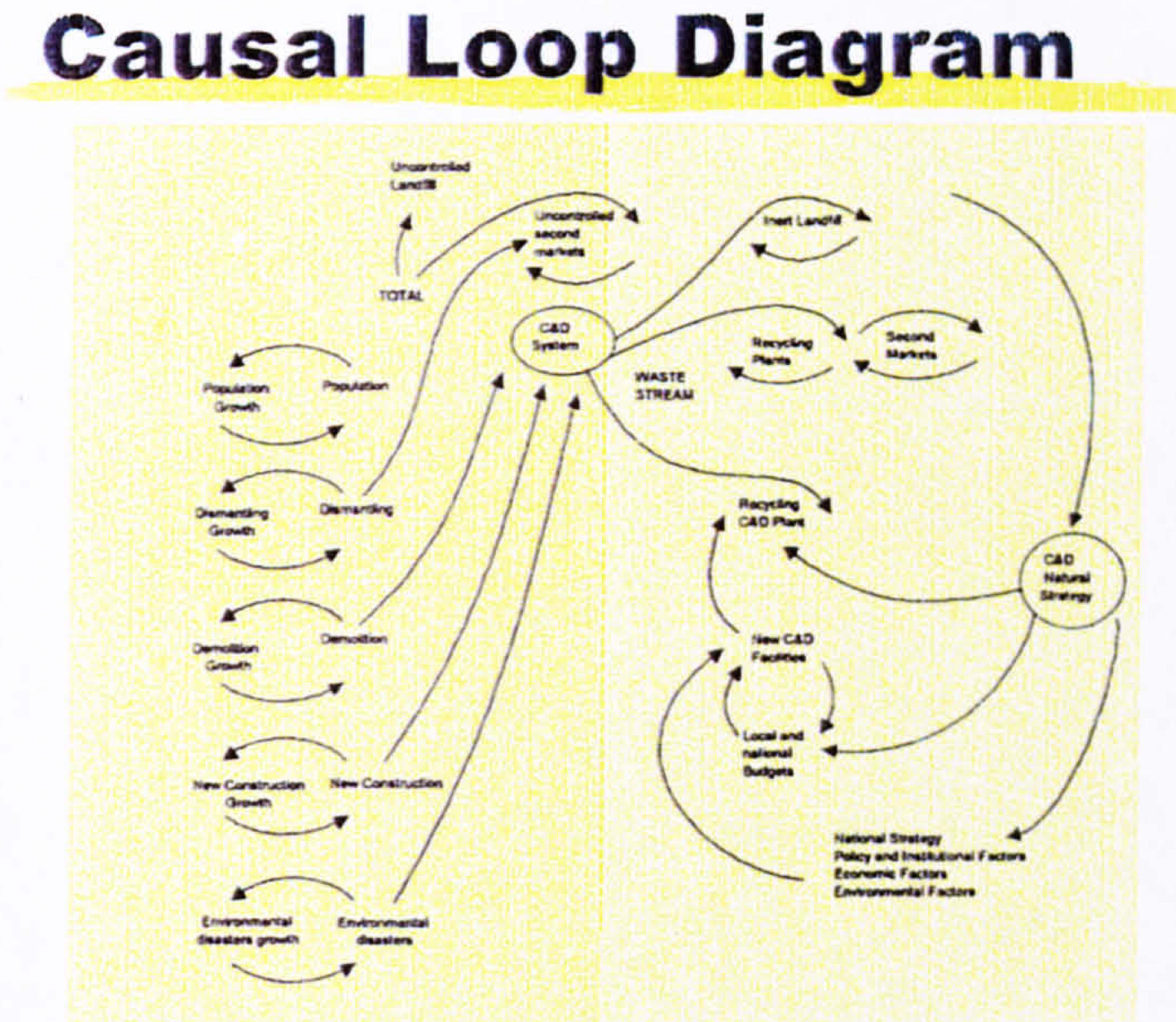
Figure 9.7 – Material flows in producing and recycling



Source: Roberts et al. 1982:192, Fig. 101.

Figure 9.8 illustrates a general cognitive map of the conceptual model for construction and demolition, the causal loop diagram. The first step of a model conceptualisation is the definition of a cognitive map, designed by causal loop diagram where the real situation is compared with a proposed future situation. This future situation is a dynamic and integrated solution based on a new policy and strategy.

Figure 9.8 – Causal Loop Diagram



Concepts (Figure 9.8) were developed combining, in a dynamic perspective, the "real world" and the "system thinking" approach. From this was developed a structured cognitive map of the Construction and Demolition Waste System. The left side of the Causal Loop Diagram presents the current situation with the construction and demolition sources and limited regulation and specification resulting in uncontrolled inert landfills and uncontrolled second markets. The right side presents an integrated and sustainable alternative. A situation with the Construction and Demolition system based upon regulation, specification, facilities and criteria to address environment concerns. This includes the feasibility and economics of recycling plants.

This is the preliminary step to develop the construction and demolition waste stream model. It is the mental definition of a dynamic system with integrated sub systems action to achieve strategic goals and targets.

Using this cognitive map with structured ideas it was possible to develop and run the dynamic model that simulated scenarios. It represented the construction and demolition waste management situation in Portugal and was able to forecast future scenarios. The dynamic process tested and monitored a policy based on a well-defined strategy.

The quantitative and qualitative information and data for the dynamic model was taken from a number of sources. The first was the case studies reported in Chapter 7. The second was the Lisbon area multiple case studies. The survey developed on construction and demolition wastes collected by Lobbe Derconsa AS (1997), and the results of the questionnaire to the working group about contractor attitudes and behaviour. This was reported in Chapter 8. The other source of information and data was the work by ADEME (1998). According to the Group (1998) this last source of information and data is the most important and up-to-date study at European Union level of this waste stream. The survey from ADEME (1998) has been developed since 1990 and extended over the 22 regions of France. It is a joint project with the Centre Experimental de Recherches et dÉtudes du Bâtiment et des Travaux'Publics (CEBTP) and the Association des Industries de Materiéaux, Composant et Equipement pour la Construction (AIMCC).

The characteristics of the building industry and civil construction in the southern European countries are similar to the ADEME study area and this was a good reason to use the information from ADEME (1998). The simulation can be developed using data from a geographic area with different characteristics and the input data changed, as it becomes available for the new area. It is a characteristic of system dynamics and it represents a powerful tool to model the construction and demolition waste stream. With feedback from research and the "real world" the pilot model can be updated to overcome data shortcomings over time.

Table 9.1 shows the construction and demolition waste information by region, classified by source, type and per inhabitant.

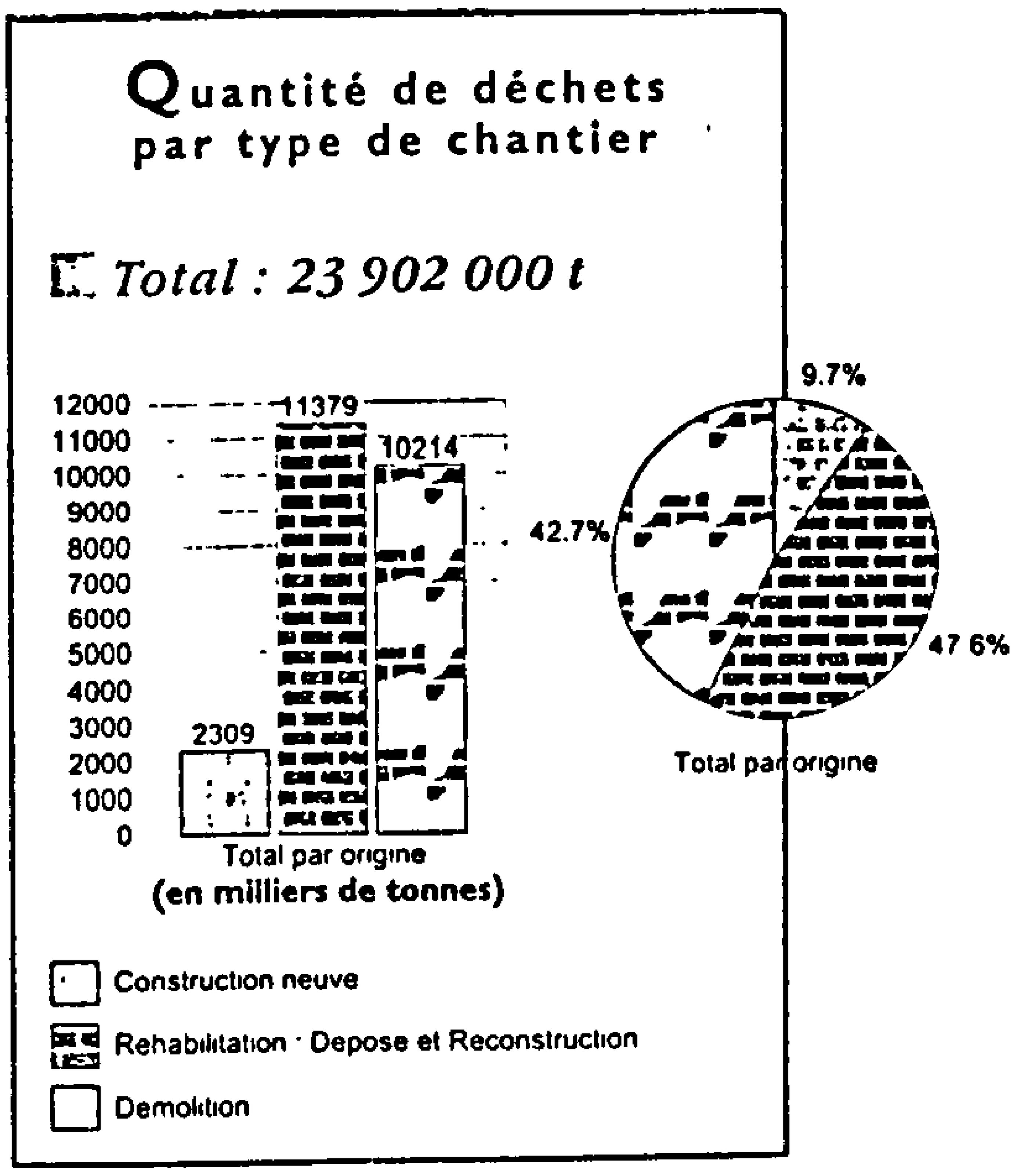
Table 9.1 – Type of Construction and demolition waste in France by region and *per capita*

DÉMOLITION	CONSTRUCTION NEUVE	RÉHABILITATION	RÉGION	DÉCHETS INERTES	DÉCHETS INDUSTRIELS BANALS	DÉCHETS INDUSTRIELS SPÉCIAUX	EMBALLAGES		
423	85	321	ALSACE	545	228	46	10	829	0,51
322	101	506	AQUITAINE	608	243	65	13	929	0,33
322	34	190	AUVERGNE	355	157	28	5	545	0,41
202	51	273	BOURGOGNE	343	140	36	7	526	0,33
598	101	457	BRETAGNE	757	322	65	13	1 156	0,41
138	80	493	CENTRE	464	177	60	11	712	0,30
156	41	225	CHAMPAGNE-ARDENNE	275	112	29	5	421	0,31
9	7	48	CORSE	42	16	6	1	64	0,26
211	33	182	FRANCHE-COMTÉ	279	119	25	4	427	0,39
3 650	615	3 024	ILE-DE-FRANCE	4 764	2 024	422	79	7 289	0,68
552	71	347	LANGUEDOC-ROUSSILLON	633	276	51	9	969	0,46
55	19	99	LIMOUSIN	113	45	13	2	173	0,24
248	71	385	LORRAINE	460	185	49	9	704	0,31
359	89	428	MIDI-PYRÉNÉES	573	234	57	11	876	0,36
478	109	517	NORD-PAS-DE-CALAIS	723	298	69	14	1 104	0,28
74	64	272	BASSE-NORMANDIE	270	98	33	8	409	0,29
28	70	314	HAUTE-NORMANDIE	271	94	37	9	411	0,24
165	129	597	PAYS-DE-LA-LOIRE	586	217	73	16	892	0,29
64	72	415	PICARDIE	360	132	49	10	551	0,30
83	51	291	POITOU-CHARENTES	278	105	35	-	425	0,27
827	171	818	PACA	1 188	495	111	22	1 816	0,43
1 250	246	1 178	RHÔNE-ALPES	1 750	732	161	31	2 674	0,50
10 214	2 309	11 379	TOTAL	15 635	6 451	1 521	296		

Source: ADEME 1998

Classic sources of the waste stream are considered by ADEME (1998). Four types of wastes, special industrial wastes, simple industrial wastes, inert and packaging wastes were identified. The French sources and quantities of construction and demolition waste are shown in Figure 9.9. It presents the average quantities of construction and demolition waste in million of tons and by percentage per annum deriving from different construction activities. The total waste from the three sources is 23,902,000 tons.

Figure 9.9 – Sources and quantities of construction and demolition waste by source in France



Source: ADEME (1998:Vol.1:2)

The different sources of the waste stream were classified as new construction, rehabilitation and demolition (ADEME 1998). In the surveys undertaken from 1990 to 1994, the following percentages from each source were recorded (Figure 9.8):

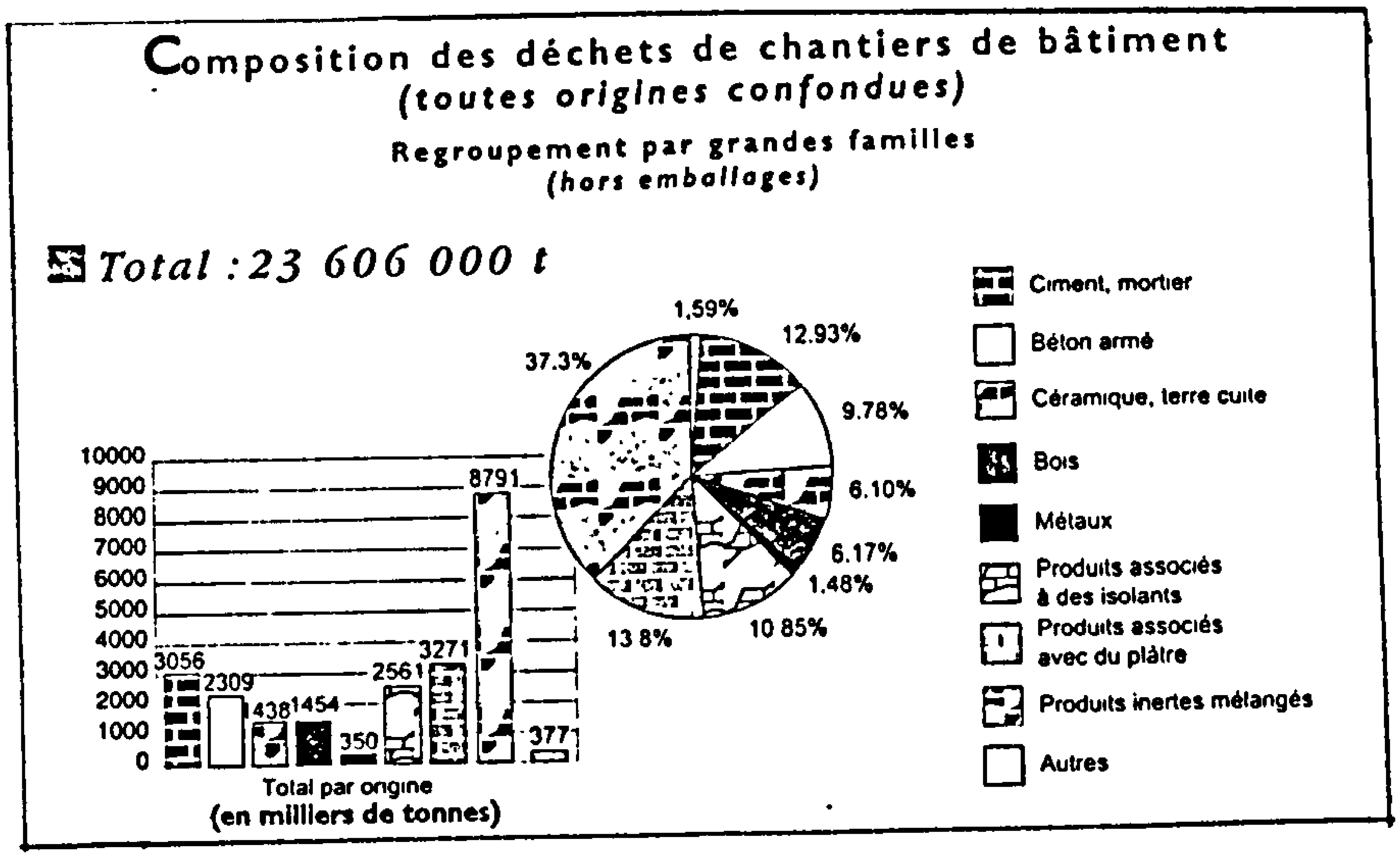
1 – New construction............................ 9.7 %

2 – Rehabilitation..47.6 %

3 – Demolition..42.7 %

The four types of wastes previously presented in Figure 9.12 were identified within each source. The three types of waste, special industrial wastes, simple industrial wastes and inert waste was further sub-divided and shown in Figure 9.10, ADEME (1998).

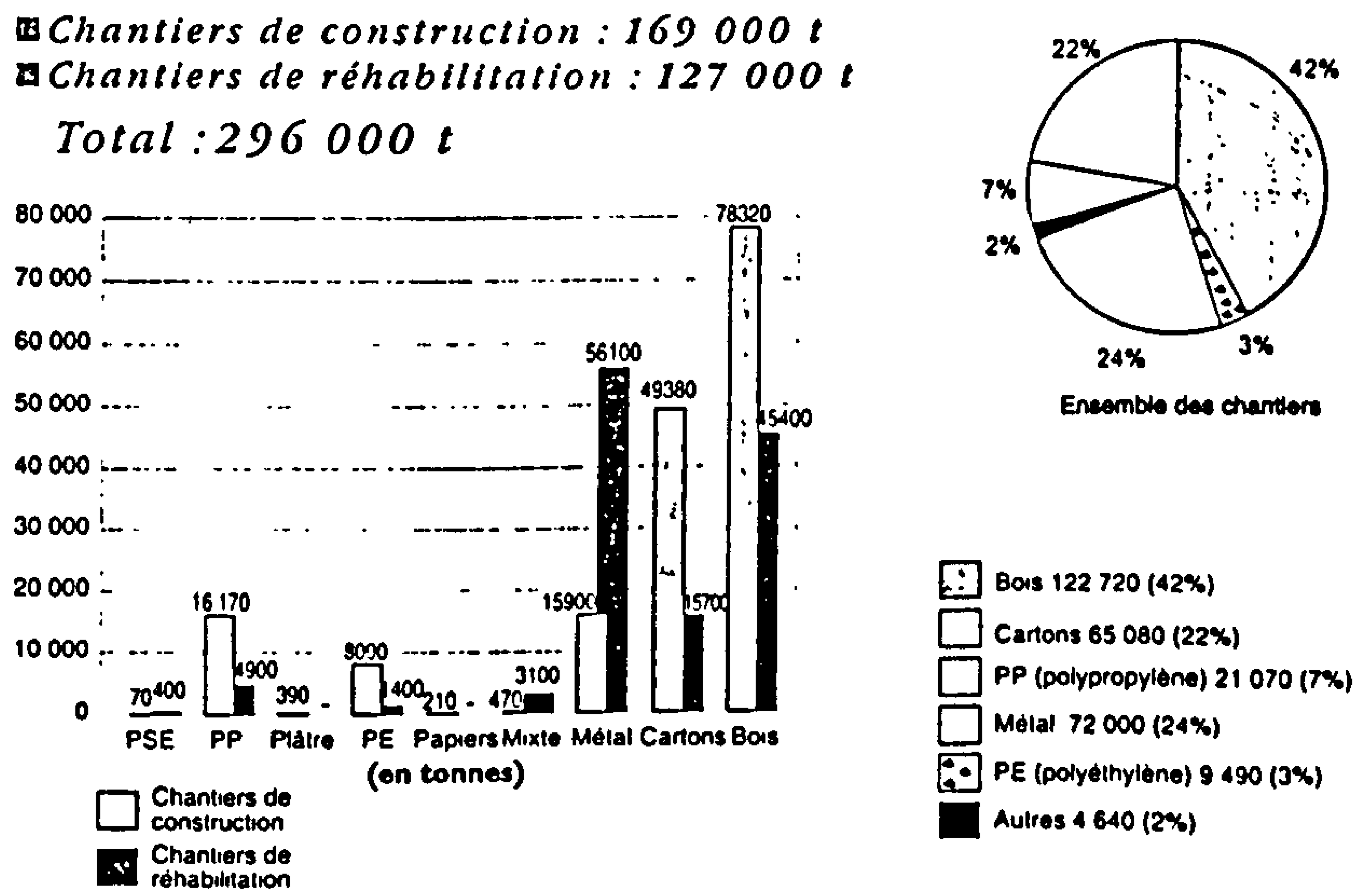
Figure 9.10 – Construction and demolition waste Type 1,2 and 3 classification by nature in France



Source: ADEME 1998:Vol.1:6.

The ADEME study presented Type 4 waste, packaging waste separately in detailed terms and is shown in Figure 9.11. As it was focussed on the packaging waste this classification was not considered in the model as it did not match the Portuguese experience.

Figure 9. 11 – Construction and demolition waste, Type 4 characterisation and quantification in France

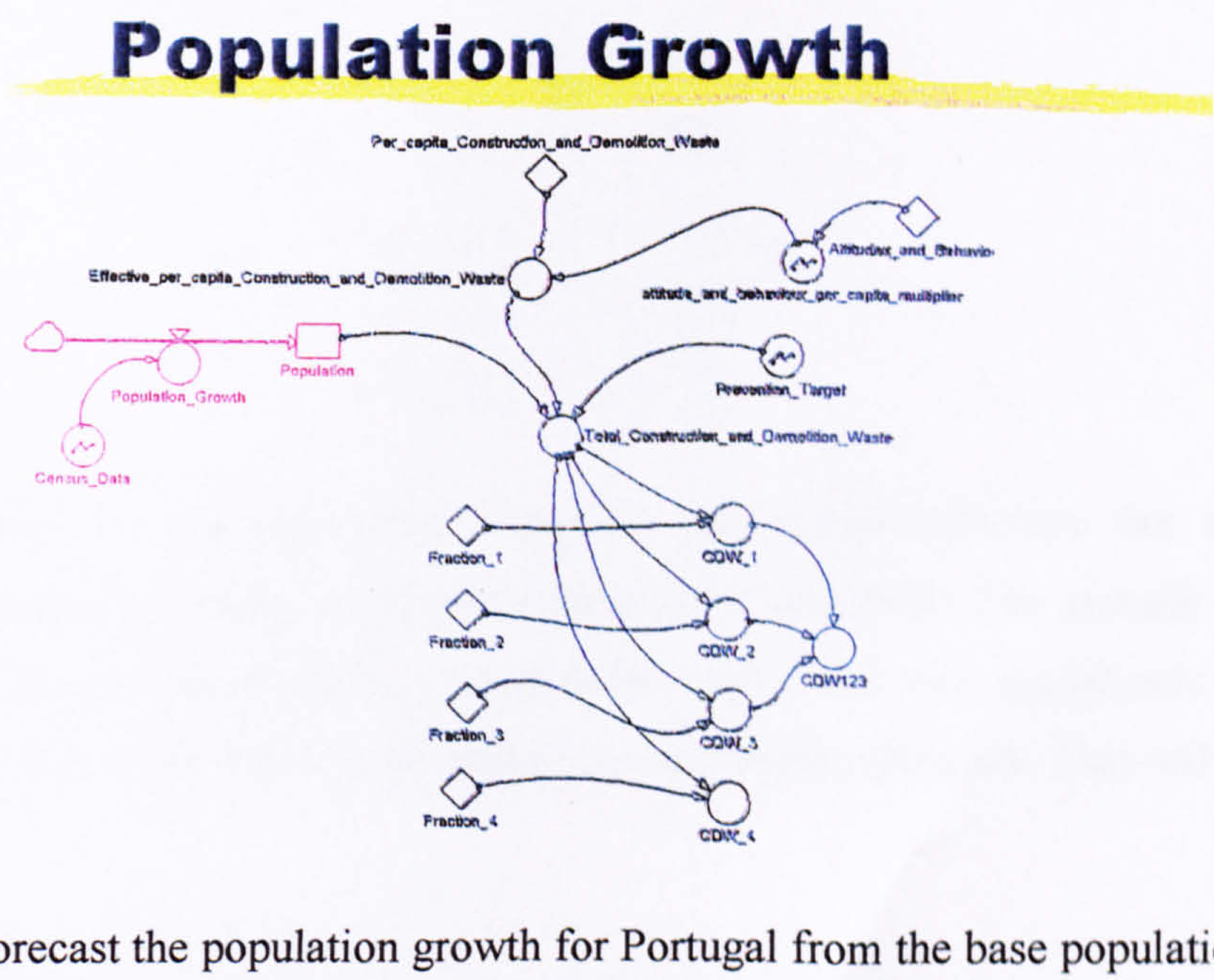


Source: ADEME 1998:Vol.1:6.

According to Moavenzadeh (1993), the constitution of the European Union construction and demolition waste stream is 37% masonry, 37 % concrete, 2 % timber, 0.3 % steel and 3.7 % others. These percentages are significantly different from those presented in Figure 9.9 from the ADEME (1998) studies. The *per capita* multipliers are not representative of the real construction and demolition waste production as discussed earlier. The ADEME percentages were used to define the structure of the construction and demolition waste in the dynamic model as they were seen to be more likely to represent the Portuguese situation. The model needs hard construction and demolition waste stream data in order to run and to enable the simulation to be studied over time.

Taking the waste stream characteristics from the ADEME (1998) studies and deriving the structure of the dynamic model the following steps were needed to define the quantities. Notwithstanding the deficiencies of the methodology it was necessary to evaluate and forecast the population and define the per capita multiplier. On this first phase of model conceptualisation, a source, the dynamic population growth to a stock of population was created from the INE (1998) census (red lines on left of Figure 9.12).

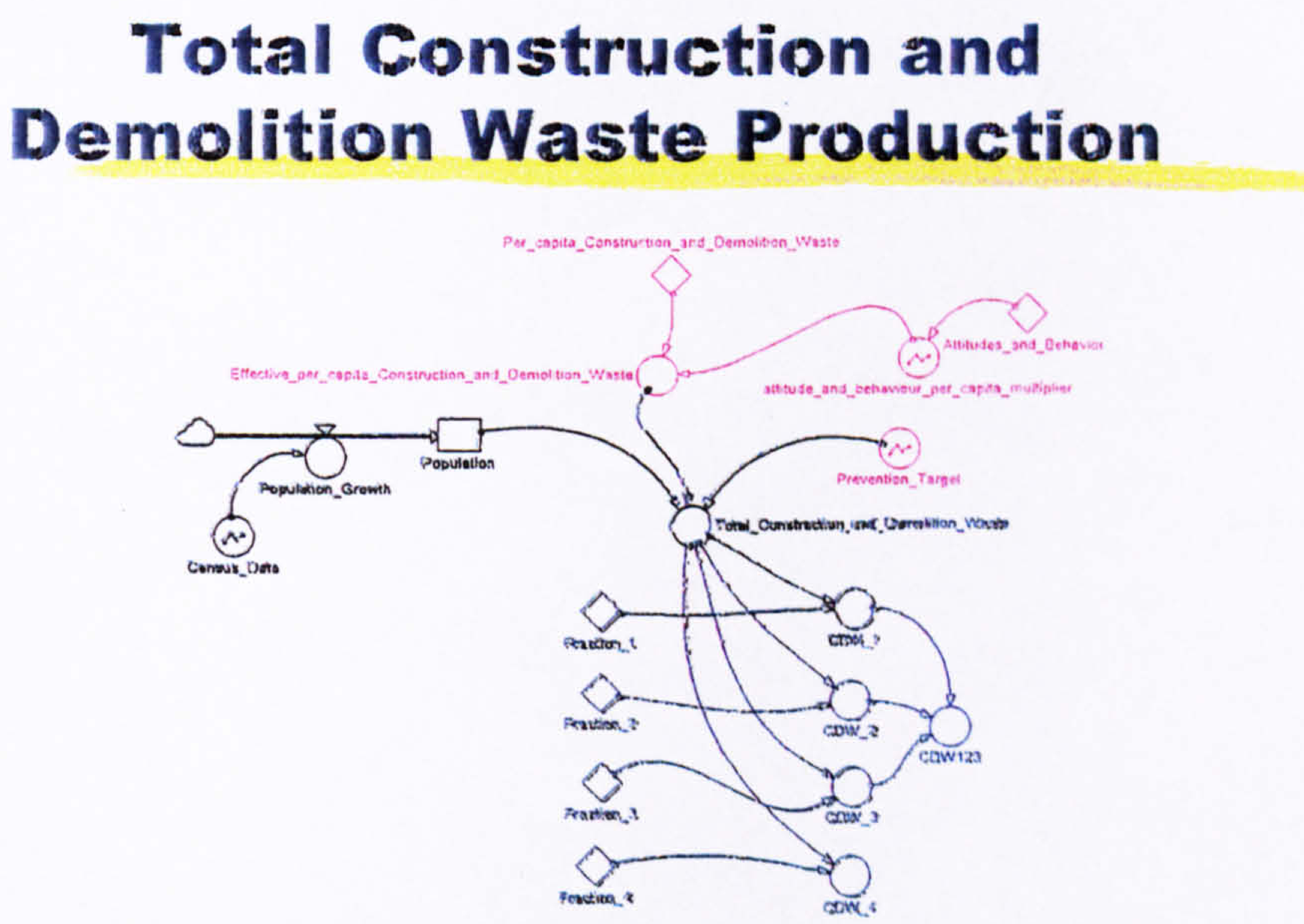
Figure 9.12 – Population Growth



INE (1998) forecast the population growth for Portugal from the base population for 1997. This data was entered into the dynamic model. Figure 9.12 highlights the Census Data and Population Growth variable in the Population stock (red line) in the dynamic model.

The *per capita* construction and demolition multiplier of 0.325 ton/year was used in the calculation. This figure was proposed by Group (1998) to the European Union as applicable to Portugal and Spain. The prevention rate from the National Solid Waste Strategy (MA/INR 1997) of 2.5 and 5.0 to the years 2000 and 2005 were used. Figure 9.13 shows this part of the model, highlighted in red. The prevention rate is variable it can be influenced by the attitude and behaviour multipliers. The second phase of model conceptualisation links these issues with the population issues creates the amount of Total Construction and Demolition Waste.

9.13 – Total Construction and Demolition Waste Production

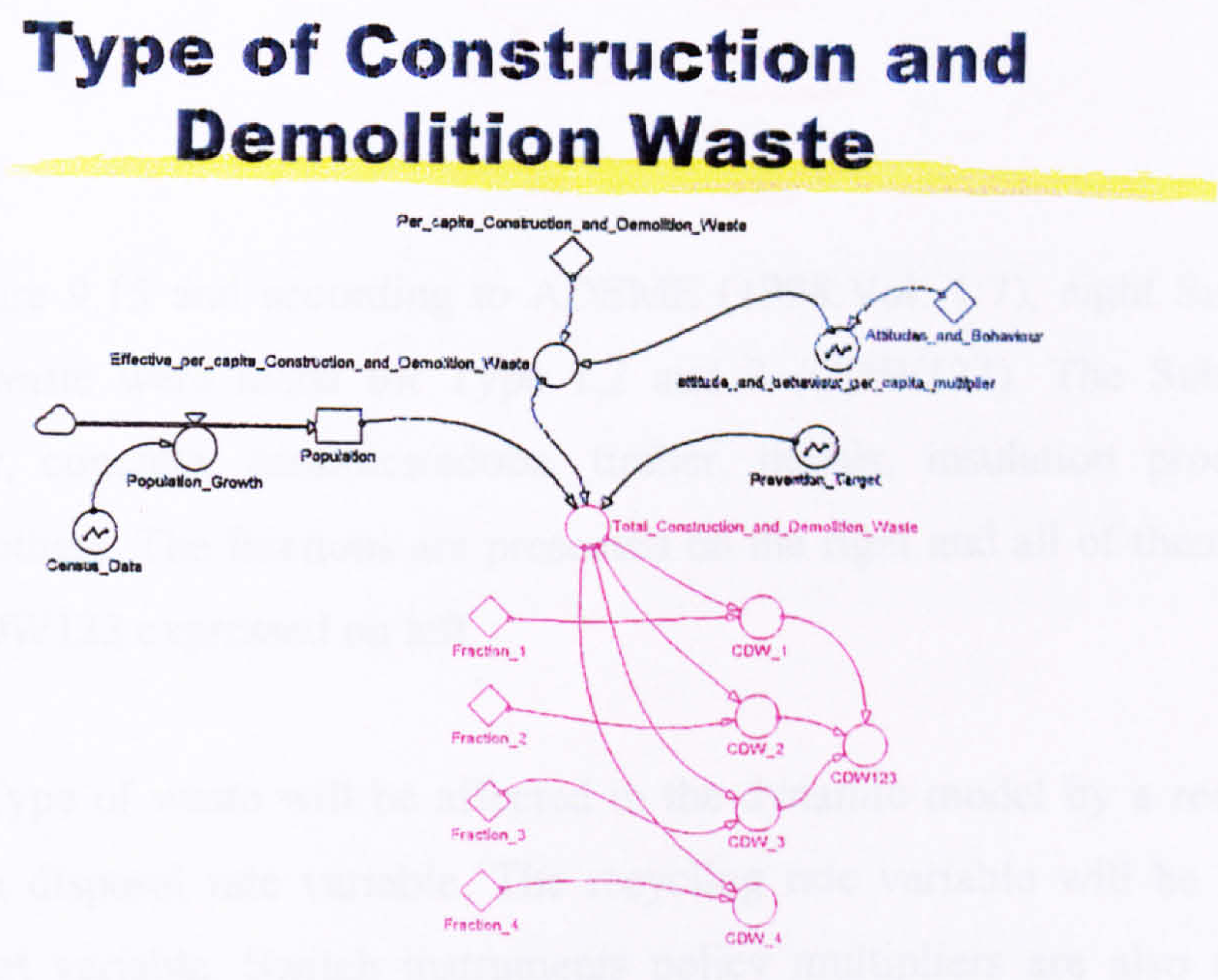


It is important to consider other variables that could influence the total construction and demolition waste produced between 1999 and 2005. The attitude and behaviour variable need to be considered. A rate of between 1 and 5 for the attitude and behaviour variable was a first attempt to define the community position. This will be discussed later.

In the dynamic model all fractions, the rehabilitation fraction (Rehab. Fract. 1), discussed later.

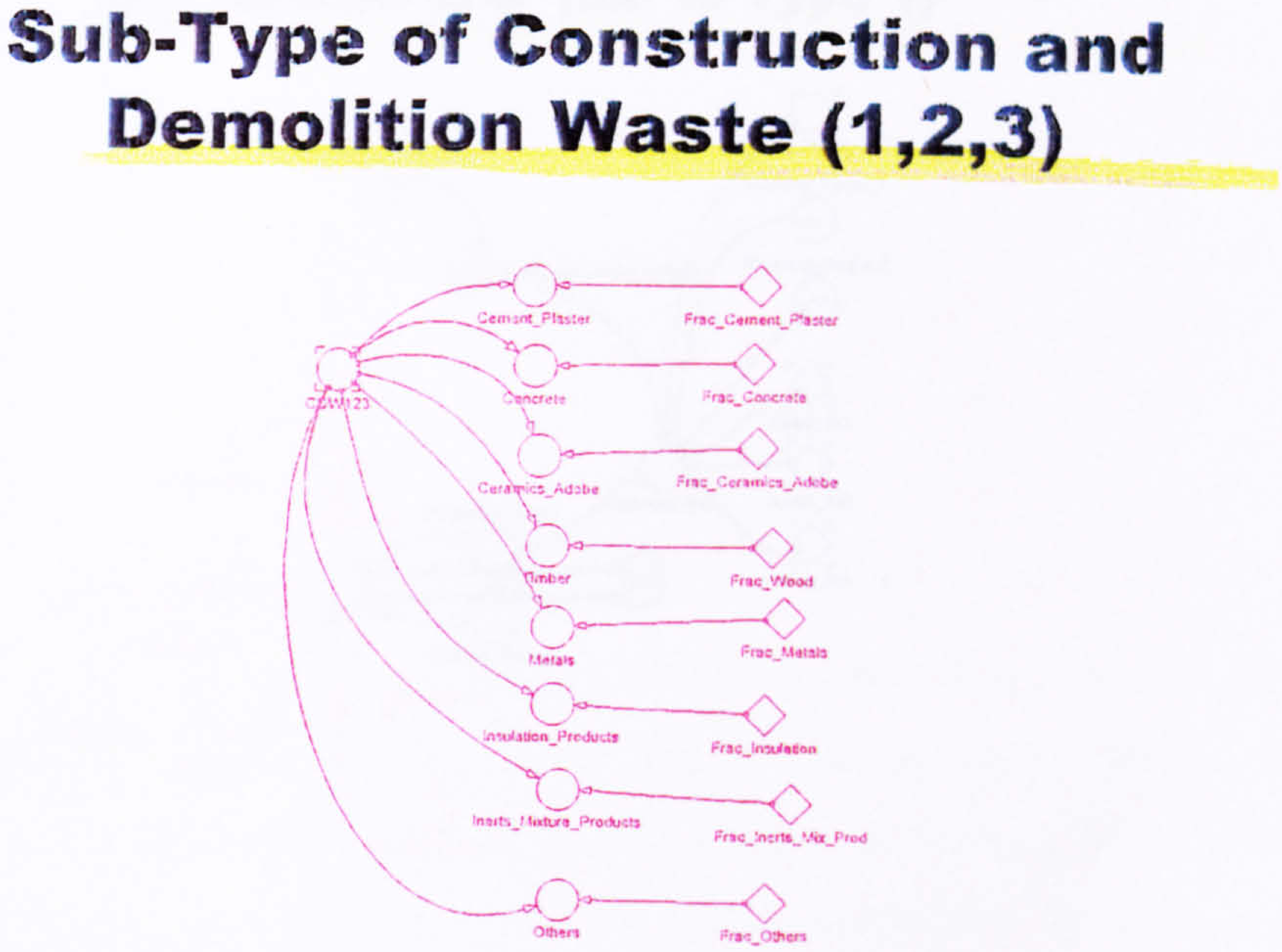
In the dynamic model all fractions, the rehabilitation fraction (Rehab. Fract. 1), the construction fraction (Constr. Fract. 1) and the demolition fraction (Demo. Fract. 1), are related to each Type of waste (1,2,3 and 4) and these will determine the consequent amount of wastes. The wastes will be summed, and a variable CDW represents the amount of construction waste for each Type of waste as shown in Figure 9.13. The red lines of the Figure 9.14 shows the Fraction variable to each Type of construction and demolition waste. The total Construction and Demolition Waste, CDW, is the sum of the CDW 1 to CDW 4 wastes.

Figure 9. 14 – Type of Construction and Demolition Waste



The classification of the Type of Construction and Demolition Waste has been described before and, with the exception of Type 4, is used in the model with the sub-divisions of the Types. Figure 9.15 shows the Sub-Type classification of wastes of Type 1,2 and 3 (CDW123).

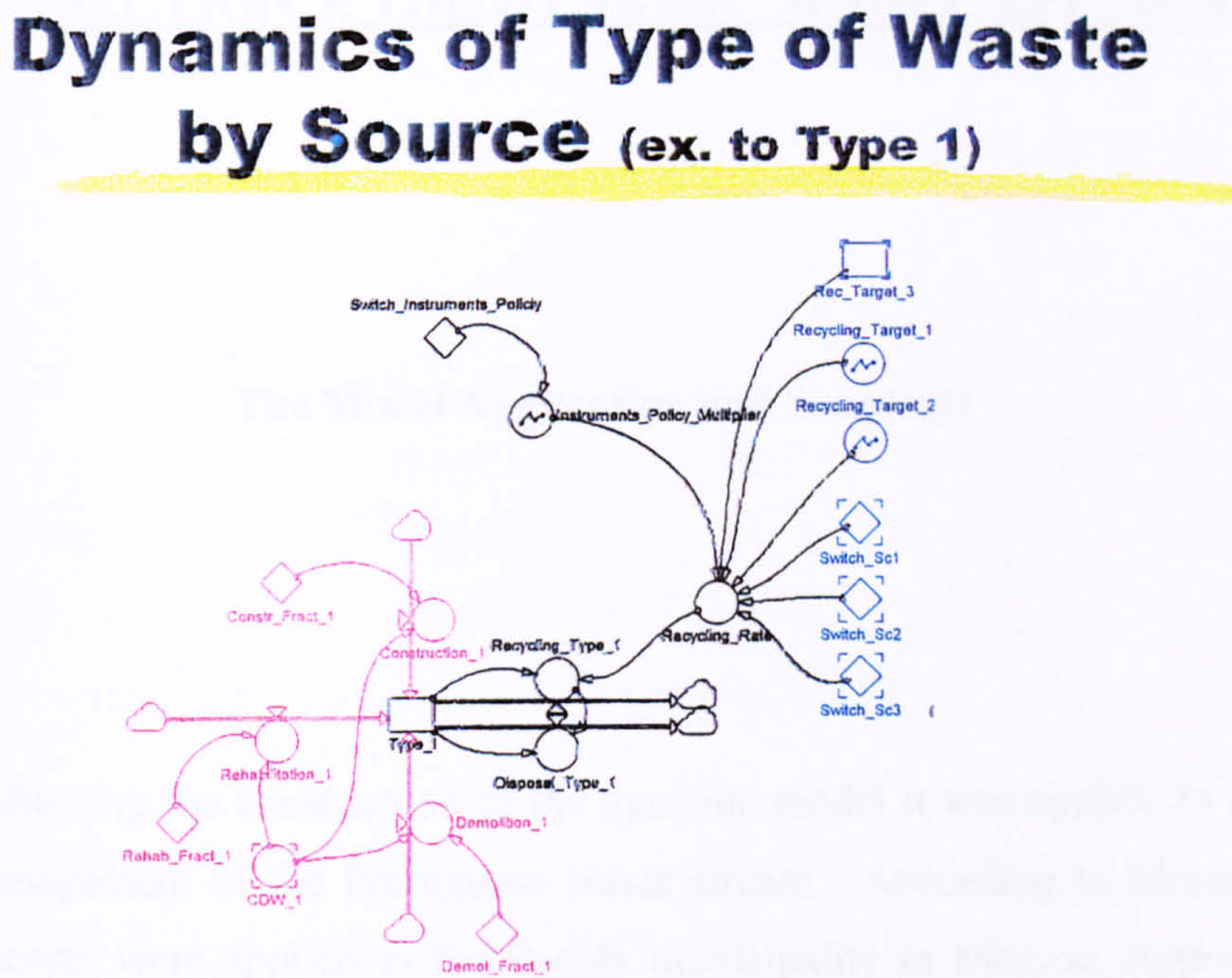
Figure 9. 15 – Sub-Type of Construction and Demolition Waste (1,2,3)



In Figure 9.15 and according to ADEME (1998:Vol. 1:7), eight Sub-Types of construction waste were made for Type 1,2 and 3 (CDW123). The Sub-Types are cement/plaster, concrete, ceramics/adobe, timber, metals, insulation products, inert mixtures and others. The fractions are presented on the right and all of them contribute to the total CDW123 expressed on left.

Each Type of waste will be affected in the dynamic model by a recycling rate variable and a disposal rate variable. The recycling rate variable will be linked to a recycling target variable. Switch instruments policy multipliers are also used in the model. Each switch is independent of others. They identify the objective, the three scenarios developed in the model, which will be explained later. This can be seen in Figure 9.16 where red lines highlight the dynamics of the waste by source.

Figure 9.16 – Dynamics of Type of Waste by Source (Type 1)



The example shown in Figure 9.16 considers the construction and demolition waste Type 1 (special industrial construction and demolition waste) in accordance with the classification by ADEME (1998). The same approach is made for the other three Types of construction and demolition wastes and they collectively contribute to dynamic model. The map of the dynamic model and a sequence of the software presentation are in Appendix F.

The next section concerns the application and development of some scenarios within the dynamic model with a focus on the simulation of scenario 2. This scenario was chosen due its representation of the present situation in terms of recycling rate (4 %) and it uses the National strategy forecasts of a 25 % recycling rate up to the year 2005.

SECTION 3: THE DYNAMIC MODEL APPLICATION

The Model Application and Scenarios

Following the construction of the dynamic model it was applied to the problem of the management of the Portuguese waste stream. According to Sliwa (1994) the same concepts were applied to the Puebla municipality in Mexico. Approaches were developed to improve waste management. The Public Authorities resisted change and were fastened to the traditional approach to solving community problems. A similar resistance was experienced from the Lisbon municipality, in the Lisbon case studies, where this research was seen to be an "academic dream".

In the application of the model the data and information used are based on European Union figures for construction and demolition waste production and material composition. These figures reflect the different construction and demolition waste compositions of the Southern Mediterranean EU states as compared to the Northern EU states. The European Union approved the Portuguese national waste management quantified targets (MA/INR 1997) to the year 2000 and 2005.

An alternative option used the goals and targets of the Municipal Solid Waste Portuguese Strategy (MA/INR 1997) with reference to the years 1995, 2000 and 2005 (Figure 8.2, Chapter 8). The strategy set down the national goals for the construction and demolition waste stream. Three scenarios were developed. They were:

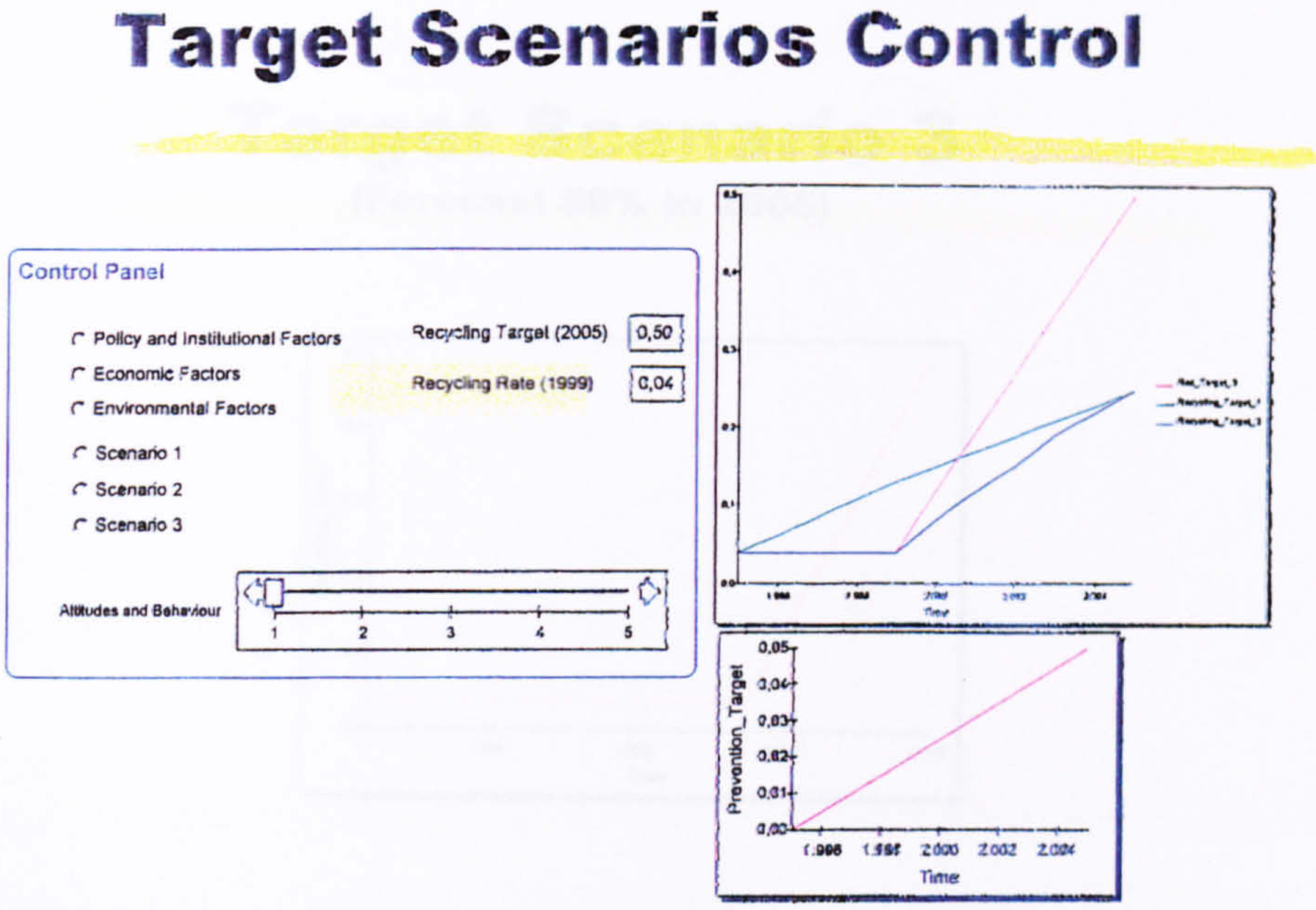
- Scenario 1. This scenario observed the strategic goals and quantified targets set down in the Plan (MA/INR 1997:64) for the years 2000 and 2005. The multi-material recycling or non-organic recycling targets are 15 % and 25 % respectively for these years. These goals and targets constitute the desired alternative option set down in the Portuguese strategy (MA/INR 1997).

- Scenario 2. This scenario observed the strategic goals and targets according the Municipal Solid Waste Strategic Plan (MA/INR 1997) but modified to the actual1999 situation. The recycling rate achieved was 4 % for multi material (without organic matter) for the years between 1995 and 1999 inclusive. This implies a much higher rate between 1999 and 2005 in order to achieve the rate of 25 % by the year 2005 (MA/INR 1997:64).

- Scenario 3. This scenario used an increased recycling rate in construction and demolition wastes. Following the example of other EU Member States up to the year 2005, recycling rates of 50 % should be possible. The objective was to achieve a target of 50 %, which was proposed by Silva and Farinha (1994).

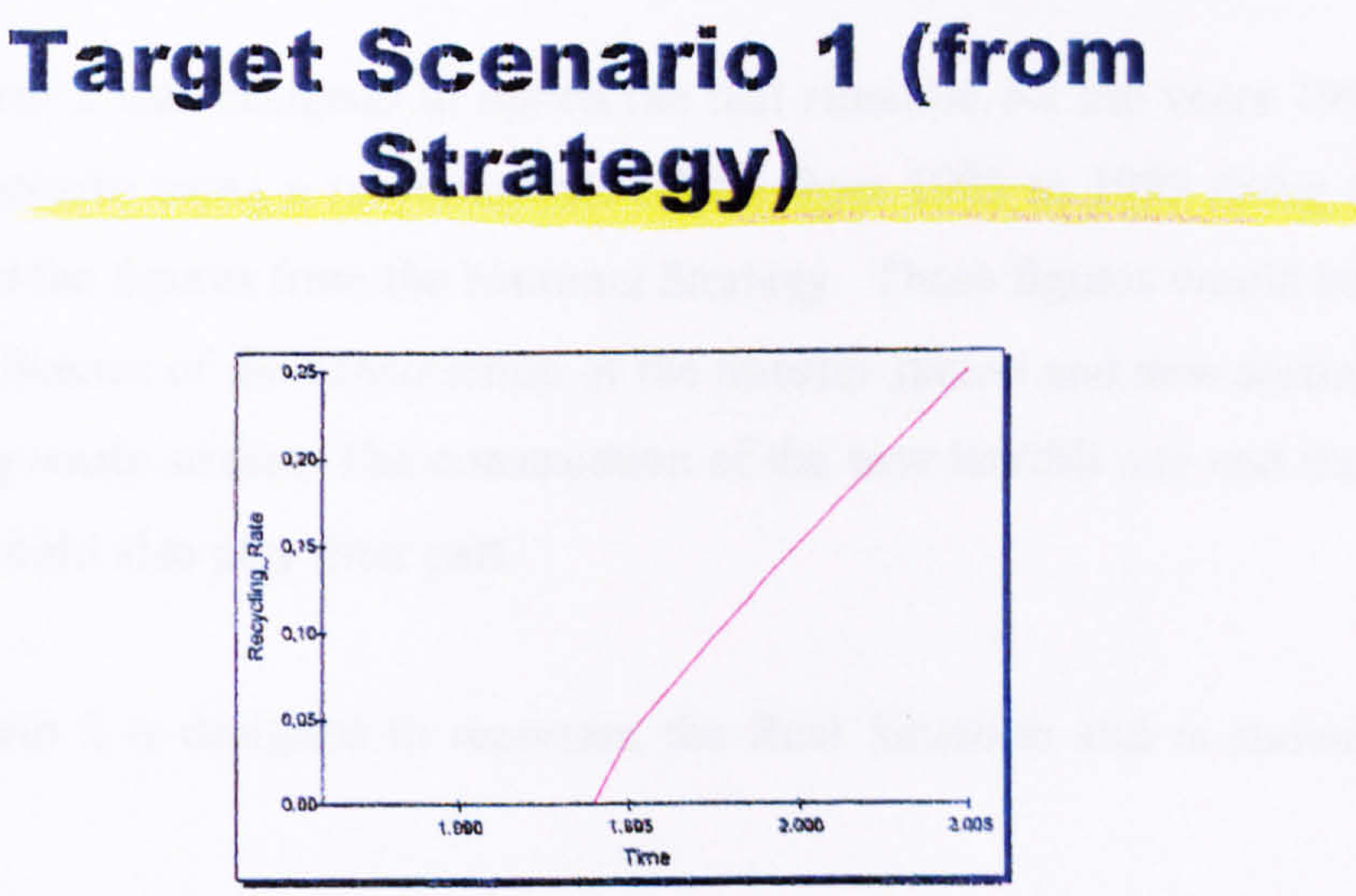
This information and data from the three scenarios forecasting was fed into the model. A Control Panel as shown in Figure 9.17 controlled target scenarios in the dynamic model. Policy and Institutional factors, economic and environmental factors were controlled according to the concepts developed for them. Other factors could be added to the model at any time. The prevention rate pattern is also shown as a straight red line in Figure 9.17. Appendix F contains tables and other information which was used to construction the dynamic model and run the simulation for these scenarios.

9.17 – Target Scenarios Control Panel



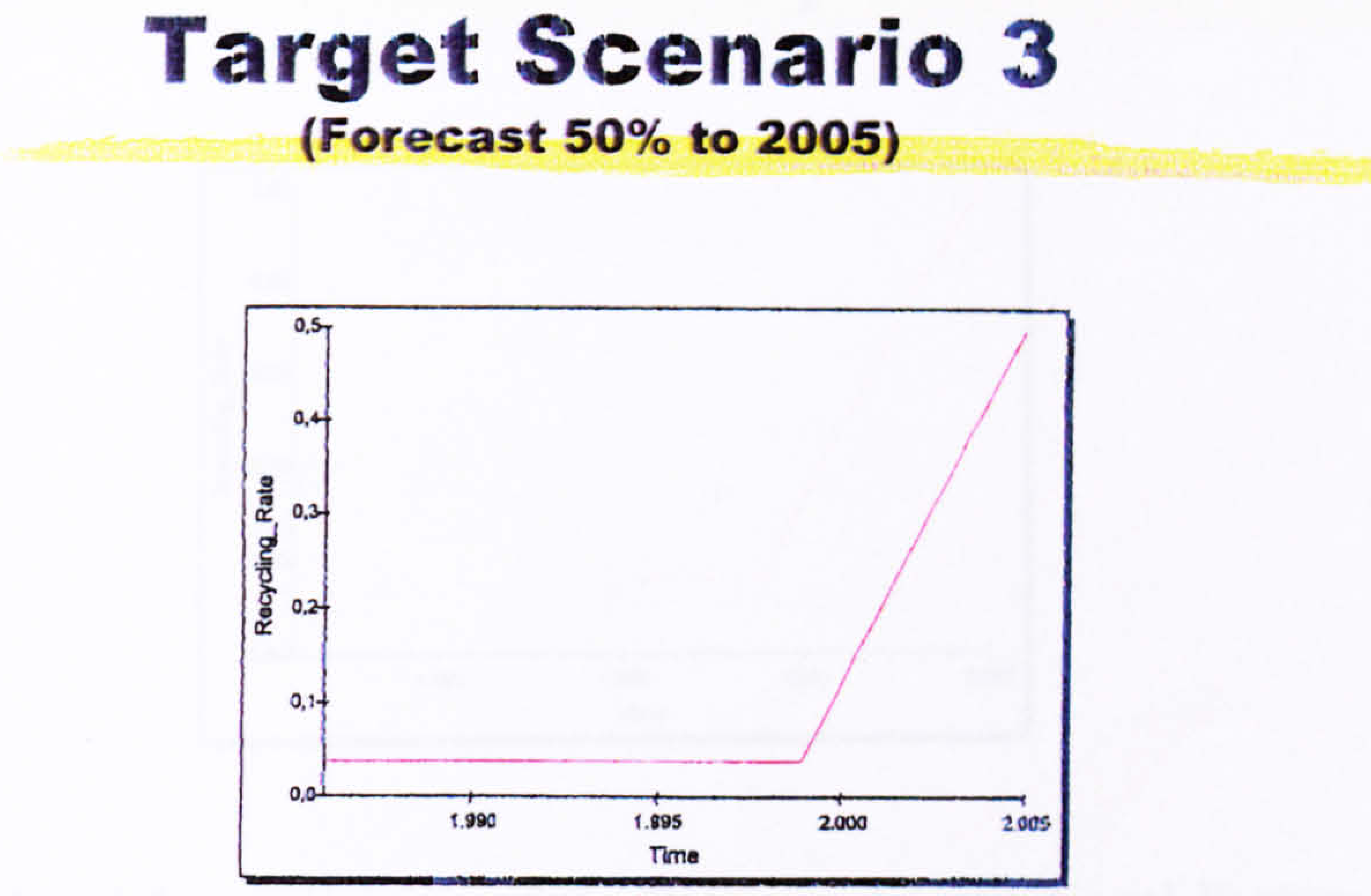
The model using the recycling rate of scenario 1, which was the scenario which used the target figures from National Solid Waste Strategy (MA/INR 1997) is shown in Figure 9.18.

Figure 9.18 – Target Scenario 1



Target scenario 3 is shown in Figure 9.19. It is a recycling a rate of 4 % to the year 1999 and rose to 50 % for the year 2005.

Figure 9.19 – Target Scenario 3

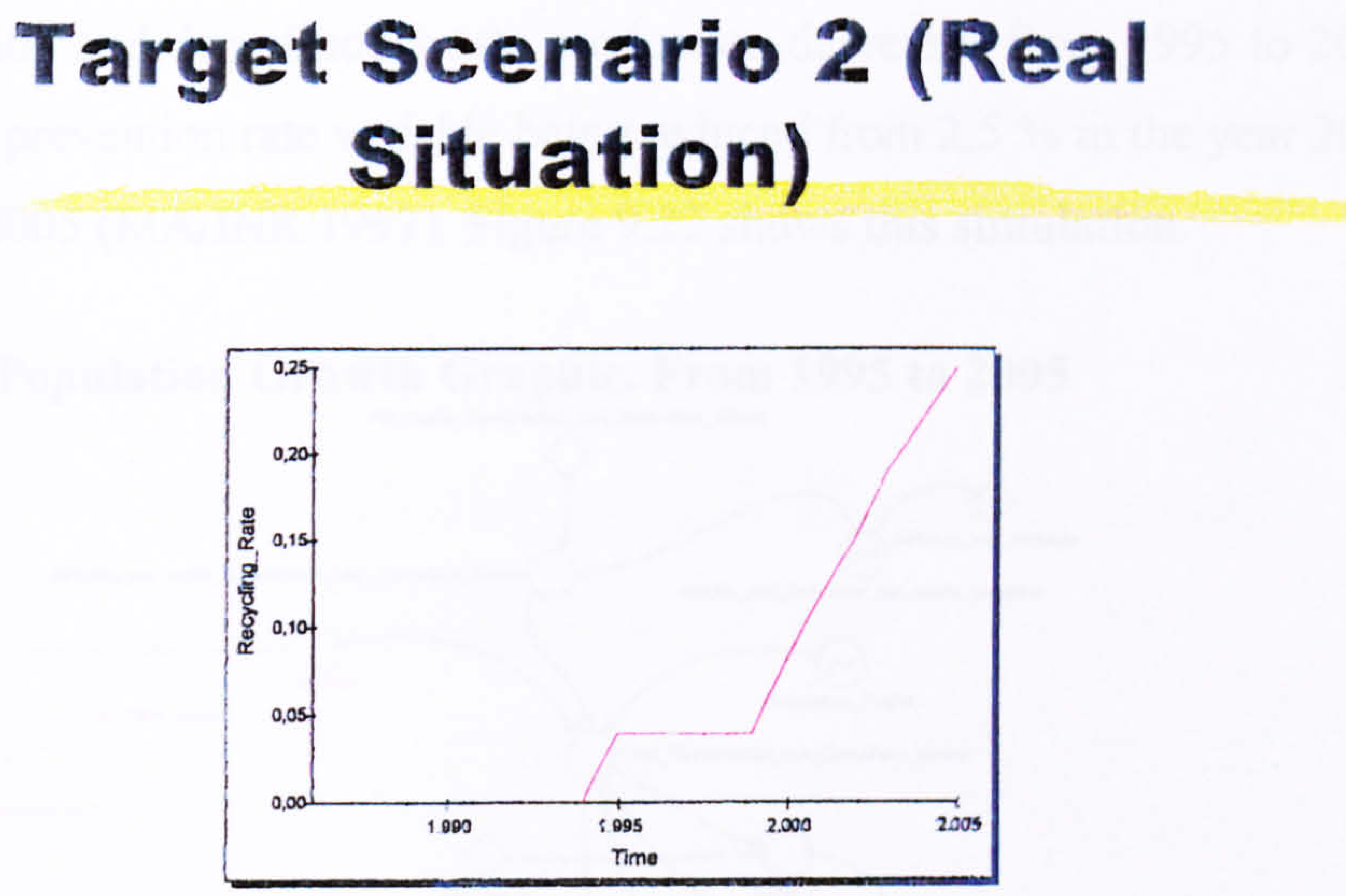


Dynamic Model Simulation to Scenario 2

Scenario 2 was designed to match the real situation for the years 1999 to 2005. The target scenario using a recycling rate of 4% from 1995 to 1999 rising to 25 % by 2005 matched the figures from the National Strategy. These figures would be due to the significant influence of the construction of the transfer station and new sorting plants on the packaging waste stream. The construction of the new landfill site and the sealing of the old tips would also play their part.

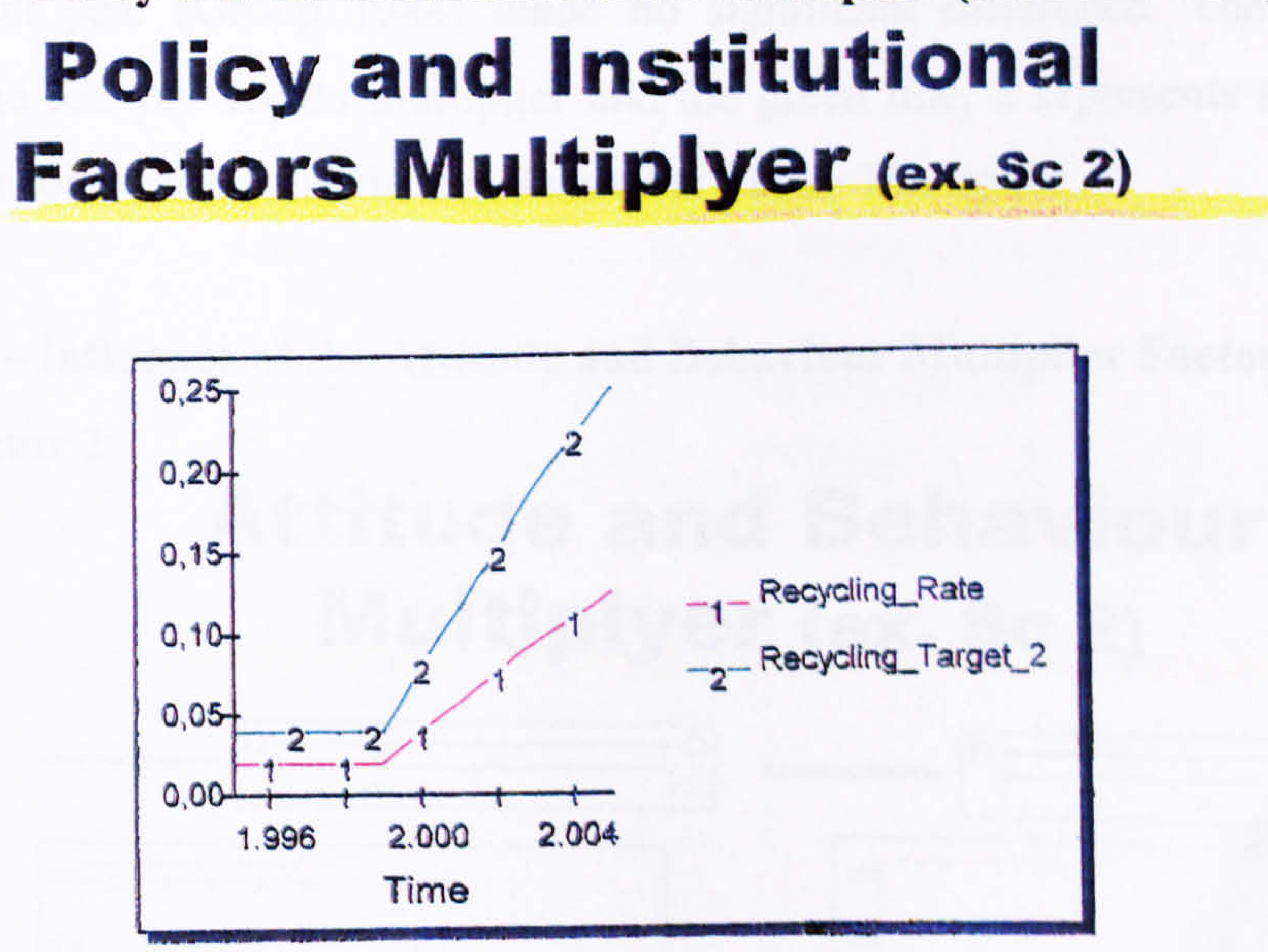
Scenario 2 is designed to represent the Real Situation and is shown in Figure 9.20.

Figure 9. 20 – Target Scenario 2 (Real Situation)



An example of the application of the Policy and Institutional Factors Multiplier is presented in Figure 9.21. With 100 % influence by the Multiplier Factor the recycling target of 25 % by the year 2005 will match the target of the National Strategy. This is shown in the model as a recycling target 2. When the Multiplier Factor was reduced to 50%, the recycling rate 1, was reduced to one half. In both cases the recycling rate is 4 % up to 1999.

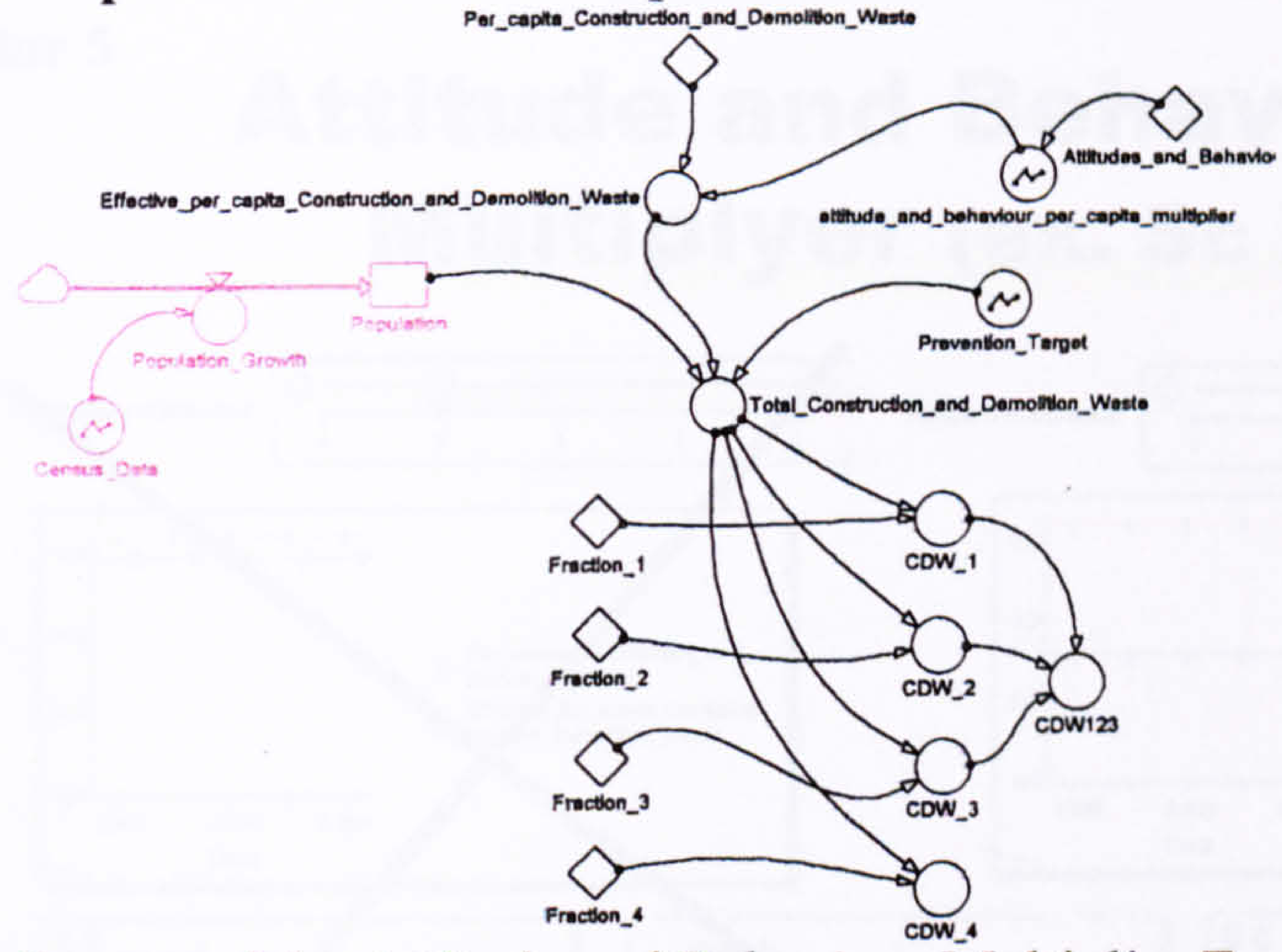
Figure 9.21 – Policy and Institutional Factors Multiplier (ex. Scenario 2)



The Population Census for the Lisbon area, forecasts a level population from

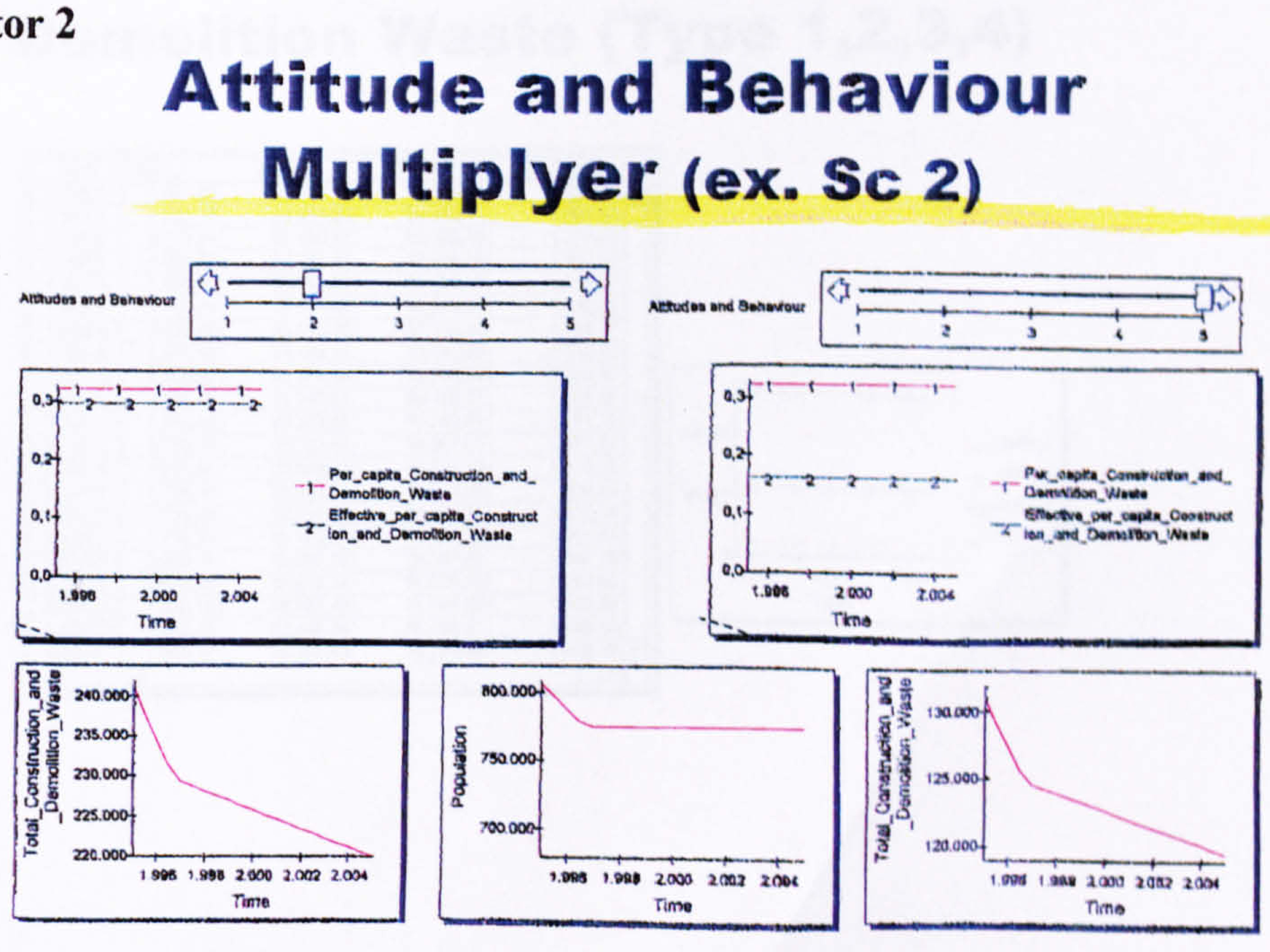
1995 to 2005. A *per capita* multiplier of 0,325-ton/yr/inhabitant was adopted and the total construction and demolition waste production decreases from 1995 to 2005. This was due to the prevention rate variable being reduced from 2.5 % in the year 2000 to 5.0 % in the year 2005 (MA/INR 1997). Figure 9.22 shows this simulation.

Figure 9.22 – Population Growth Graphic. From 1995 to 2005



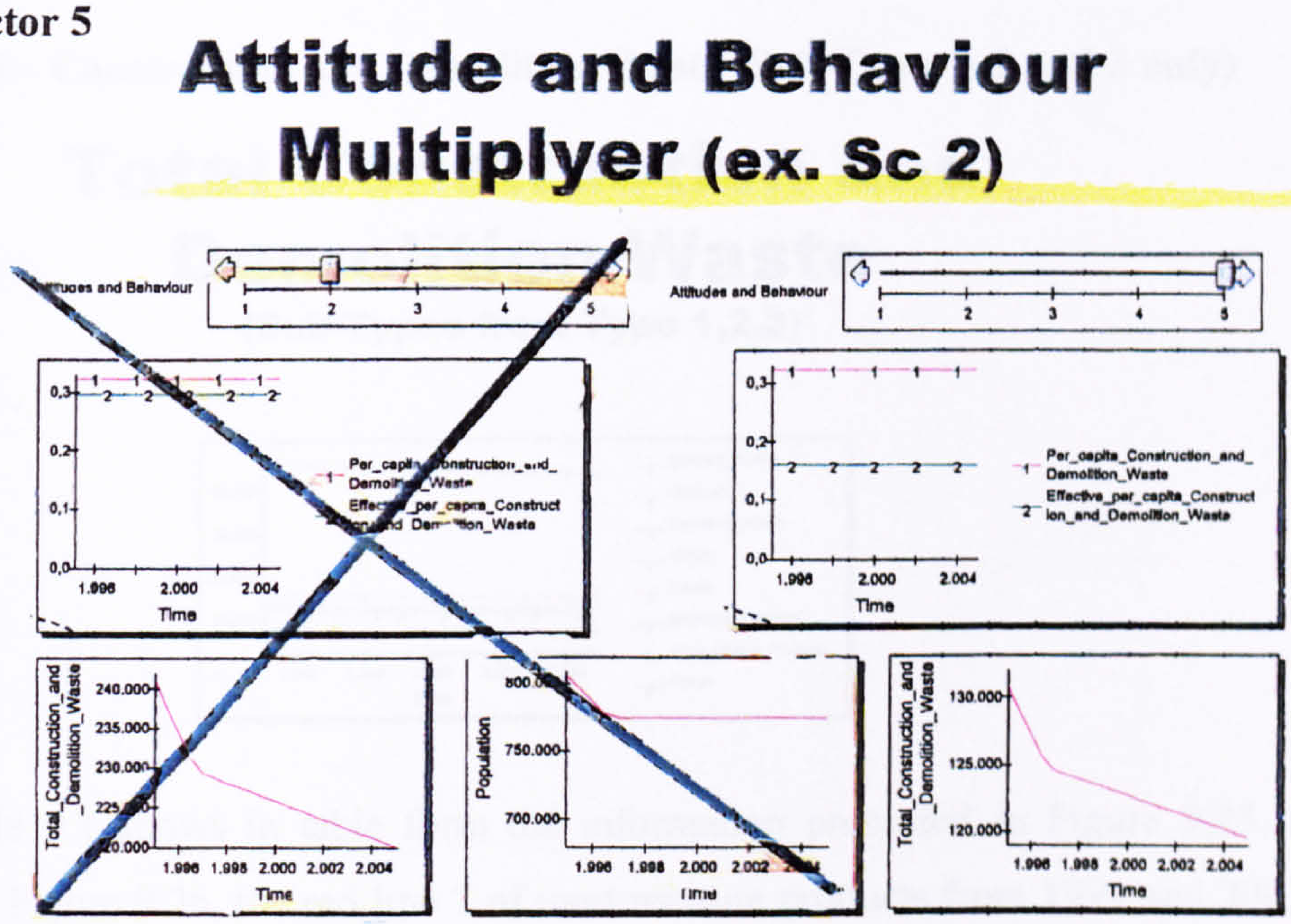
The influence of the Attitude and Behaviour Multiplier Factor, with a scale from 1 to 5, was studied with two simulations. The first simulation used a degree of influence of 2, and the second a degree of influence of 5. Figure 9.23 displays the results to the first simulation. A low level of community participation, indicated by a degree of influence of 2, and a *per capita* Construction and Demolition Waste level of 325 ton/ per inhabitant year (Group 1988) made no significant difference. The red line, 1 represents the 325 *per capita* multiplier and the green line, 2 represents the corrected figure influenced by the Attitude and Behaviour Factor Multiplier.

Figure 9.23 – Influence of the Attitude and Behaviour Multiplier Factor. Scenario 2 with a Factor 2



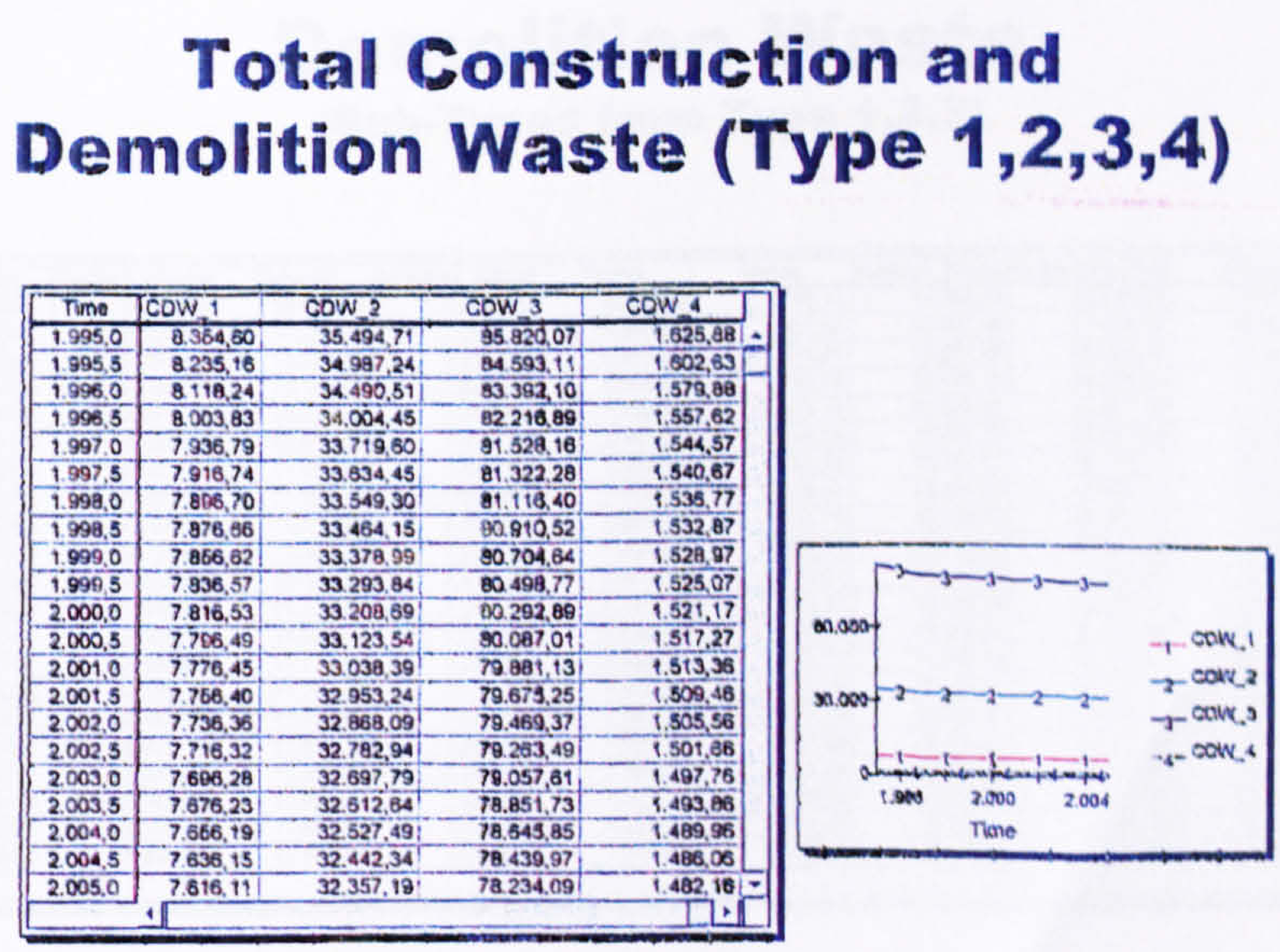
The total construction and demolition waste predicted from these figures is also presented in Figure 9.23. The same simulation was run using a degree of influence of 5 and the result is shown in Figure 9.24.

Figure 9.24 – Influence of the Attitude and Behaviour Multiplier Factor. Scenario 2 with a Factor 5



The Total Construction and Demolition Waste for the years 1995 to 2005 predicted from a Scenario 2 simulation with an Attitude and Behaviour Multiplier Factor of 5 is presented in Figure 9.25.

Figure 9.25– Total Construction and Demolition Waste (Sub-Types 1,2,3,4)



Time	CDW_1	CDW_2	CDW_3	CDW_4
1.995,0	8.364,60	35.494,71	85.820,07	1.625,88
1.995,5	8.235,16	34.987,24	84.593,11	1.602,63
1.996,0	8.118,24	34.490,51	83.392,10	1.579,88
1.996,5	8.003,83	34.004,45	82.216,89	1.557,62
1.997,0	7.936,79	33.719,60	81.528,16	1.544,57
1.997,5	7.916,74	33.634,45	81.322,28	1.540,67
1.998,0	7.896,70	33.549,30	81.116,40	1.536,77
1.998,5	7.876,66	33.464,15	80.910,52	1.532,87
1.999,0	7.856,62	33.378,99	80.704,64	1.528,97
1.999,5	7.836,57	33.293,84	80.498,77	1.525,07
2.000,0	7.816,53	33.208,69	80.292,89	1.521,17
2.000,5	7.796,49	33.123,54	80.087,01	1.517,27
2.001,0	7.776,45	33.038,39	79.881,13	1.513,36
2.001,5	7.756,40	32.953,24	79.675,25	1.509,46
2.002,0	7.736,36	32.868,09	79.469,37	1.505,56
2.002,5	7.716,32	32.782,94	79.263,49	1.501,66
2.003,0	7.696,28	32.697,79	79.057,61	1.497,76
2.003,5	7.676,23	32.612,64	78.851,73	1.493,86
2.004,0	7.656,19	32.527,49	78.645,85	1.489,96
2.004,5	7.636,15	32.442,34	78.439,97	1.486,06
2.005,0	7.616,11	32.357,19	78.234,09	1.482,16

The Total of Sub-Types 1,2,3 of the Construction and Demolition Waste is presented in Figure 9.26. Sub-Type 4 is packaging waste and is omitted from this second simulation for the reasons explained earlier.

Figure 9.26 – Construction and Demolition Waste (Sub-Types 1,2 and 3 only)

Total Construction and Demolition Waste

(Sub-Types from Type 1,2,3)

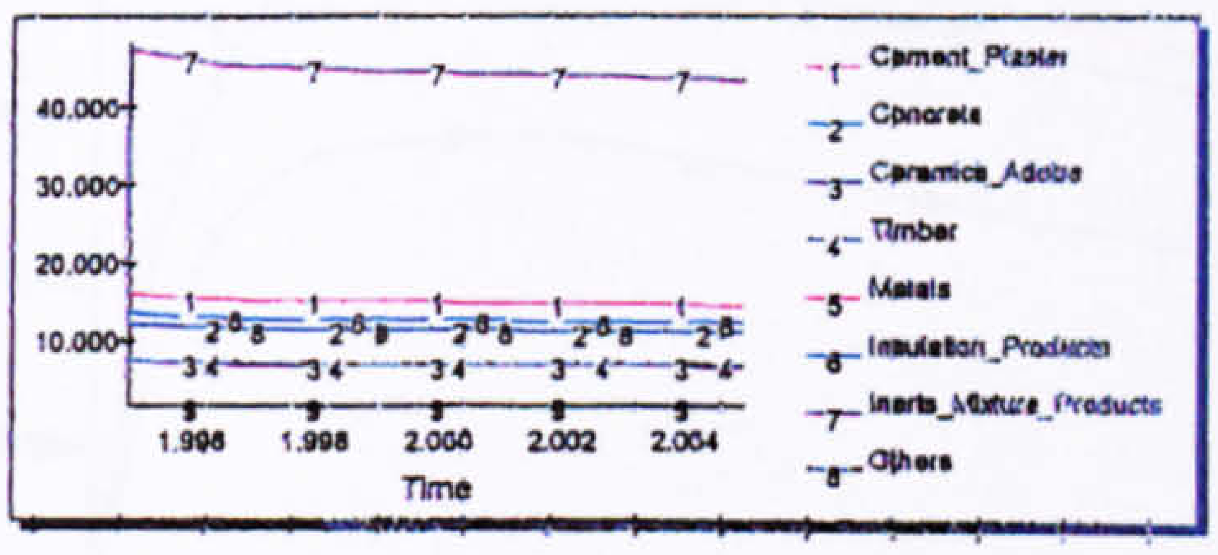


Table 9.1 shows in table form the information presented in Figure 9.25. For instance, in Figure 9.26, the red line 7 of inert mixture products from 1995 and 2005 is shown in Table 9.2 to have values of between 336,68 for 1995 and 44,091.36 tons for 2005.

Table 9.2 – Total Construction and Demolition Waste (Sub-Types 1,2,3)

Total Construction and Demolition Waste

(Sub-Types from Type 1,2,3)

Time	Cement_Plaster	Concrete	Ceramics_Adobe	Timber	Metals	Insulation_Products	Inerts_Mixture_Prod	Others
1.995,0	16.766,25	12.681,66	7.909,83	8.000,60	1.919,11	14.068,13	48.368,68	12.681,6
1.995,5	16.526,55	12.500,36	7.796,76	7.886,22	1.891,67	13.867,98	47.675,19	12.500,3
1.996,0	16.291,91	12.322,88	7.686,05	7.774,25	1.864,81	13.671,09	46.998,32	12.322,8
1.996,5	16.062,31	12.149,22	7.577,74	7.664,69	1.838,53	13.478,43	46.335,99	12.149,2
1.997,0	15.927,76	12.047,45	7.514,26	7.600,49	1.823,13	13.365,52	45.947,83	12.047,4
1.997,5	15.887,54	12.017,03	7.495,28	7.581,29	1.818,53	13.331,77	45.831,80	12.017,0
1.998,0	15.847,32	11.986,60	7.476,31	7.562,10	1.813,92	13.298,02	45.715,78	11.986,6
1.998,5	15.807,10	11.956,18	7.457,33	7.542,91	1.809,32	13.264,27	45.599,75	11.956,1
1.999,0	15.766,88	11.925,76	7.438,36	7.523,71	1.804,72	13.230,52	45.483,72	11.925,7
1.999,5	15.726,65	11.895,33	7.419,38	7.504,52	1.800,11	13.196,77	45.367,69	11.895,3
2.000,0	15.686,43	11.864,91	7.400,40	7.485,33	1.795,51	13.163,02	45.251,66	11.864,9
2.000,5	15.646,21	11.834,49	7.381,43	7.466,13	1.790,90	13.129,26	45.135,63	11.834,4
2.001,0	15.605,99	11.804,07	7.362,45	7.446,94	1.786,30	13.095,51	45.019,60	11.804,0
2.001,5	15.565,77	11.773,64	7.343,48	7.427,75	1.781,70	13.061,76	44.903,57	11.773,6
2.002,0	15.525,55	11.743,22	7.324,50	7.408,55	1.777,09	13.028,01	44.787,54	11.743,2
2.002,5	15.485,32	11.712,80	7.305,53	7.389,36	1.772,48	12.994,26	44.671,51	11.712,8
2.003,0	15.445,10	11.682,37	7.286,55	7.370,17	1.767,88	12.960,51	44.555,48	11.682,3
2.003,5	15.404,88	11.651,95	7.267,58	7.350,98	1.763,28	12.926,76	44.439,45	11.651,9
2.004,0	15.364,66	11.621,53	7.248,60	7.331,78	1.758,68	12.893,00	44.323,42	11.621,5
2.004,5	15.324,44	11.591,11	7.229,63	7.312,59	1.754,07	12.859,25	44.207,39	11.591,1
2.005,0	15.284,22	11.560,88	7.210,65	7.293,40	1.749,47	12.825,50	44.091,36	11.560,8

In scenario 2, with a recycling rate of 4 % the construction and demolition waste going to landfill in 1999 is presented in Figure 9.27.

Figure 9.27 – Construction and demolition waste going to landfill from 1999 to 2005

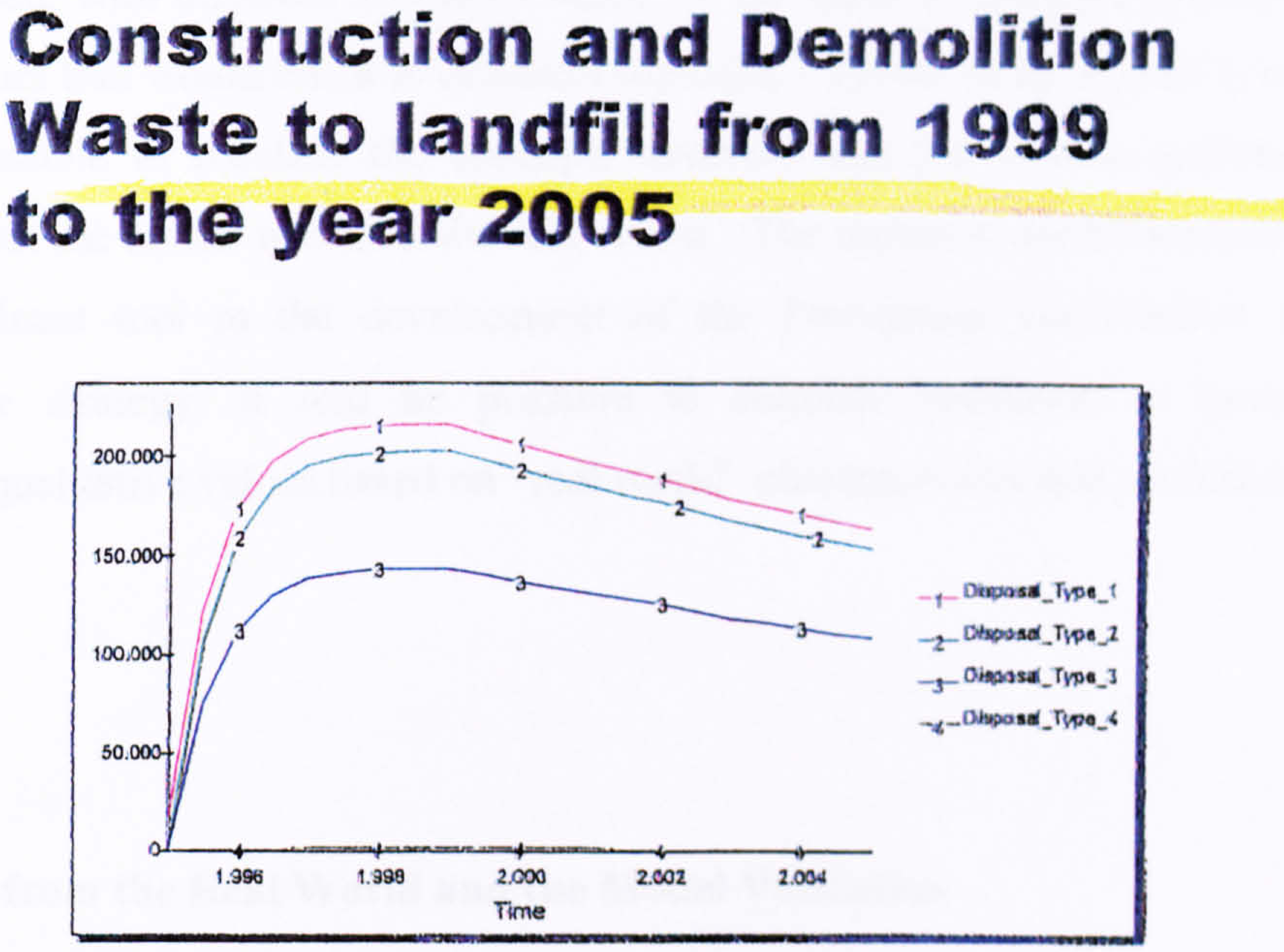
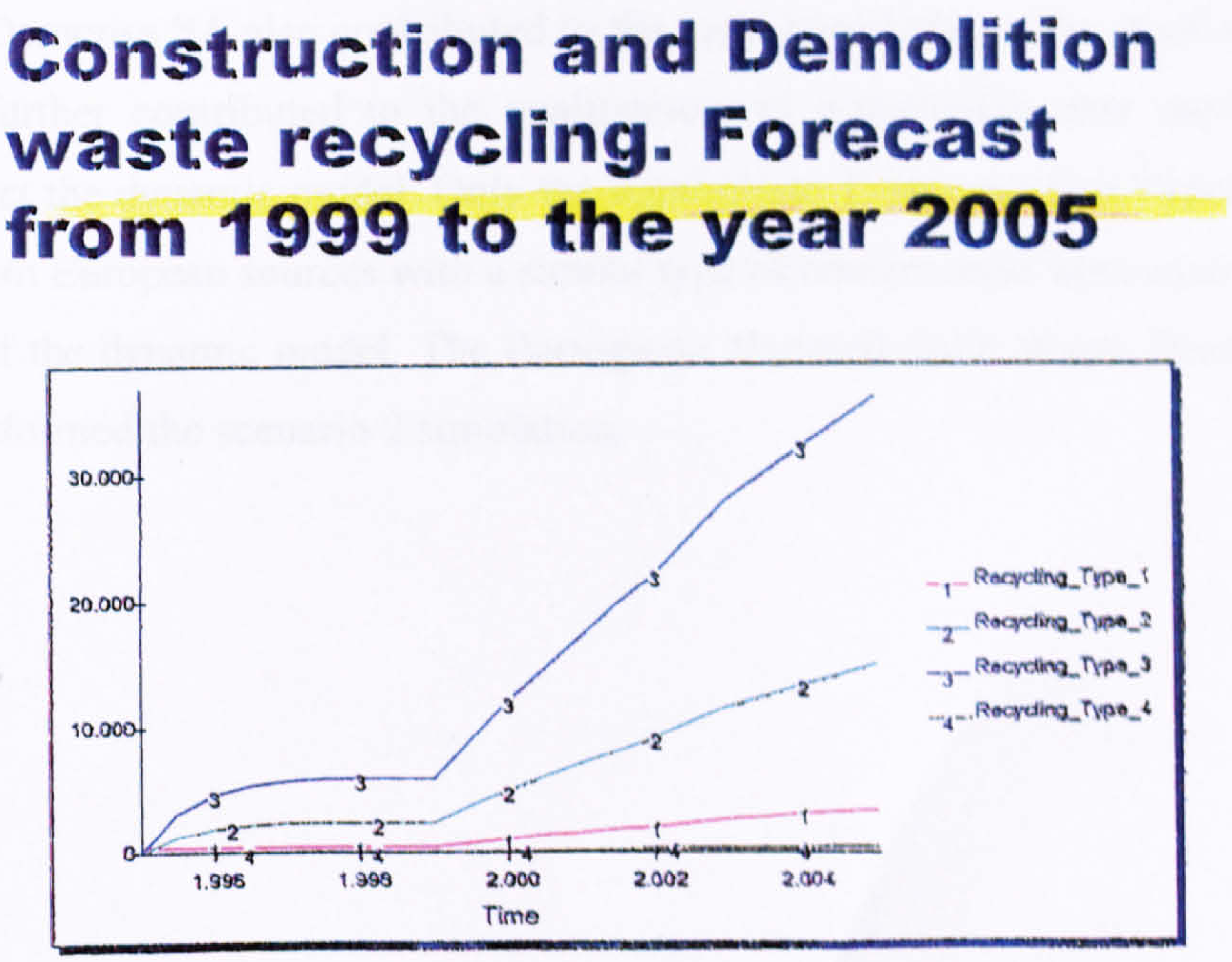


Figure 9.28 presents the simulation forecasts for the amount of construction and demolition waste going to landfill for the year 2005 based on a recycling rate of 25 % by volume.

Figure 9.28 – Construction and demolition waste to recycling. Forecast from 1995 to the year 2005



These two simulations forecast construction and demolition waste going to landfill in the years 1999 and 2005 using different recycling rates. Other simulations could be developed, with different scenarios based on the same or changed principles, concepts and values that would result in different forecasts. As the body of data is built up it will be possible to redefine the concept, structure and the chosen qualitative variables to correct the model to match the real world. The dynamic model simulation will be a significant tool in the development of the Portuguese construction and demolition waste strategy. It will be possible to simulate scenarios to forecast quantitative and qualitative values based on "real world" characteristics and tendencies.

Data from the Real World and the Model Validation

The data used in the came from a number of sources. The local sources were the five holistic Lisbon area case studies on renovation building works and the questionnaires produced by the working group. The survey undertaken with the contractor Lobbe Derconsa SA also contributed to the local knowledge. The studies by ADEME (1998) further contributed to the qualitative and quantitative data used to define and construct the dynamic model. Only the appropriate Types and Sub-Types of waste from Southern European sources with a similar type of construction were used for the development of the dynamic model. The Portuguese National Solid Waste Strategy (MA/INR 1997) informed the scenario 2 simulation.

SUMMARY

The principal conclusion from this Chapter is that the study of the construction and demolition waste stream can be studied and interpreted as a dynamic model. The relationship between the "real world" of collecting "hard" data and the system thinking of the interpretation of phenomena, should be inter linked to a "soft" but rigorous approach throughout a dynamic overview. The appropriate model can be developed after defining a clear "root definition" of the purposeful activity.

It was demonstrated that the involvement of customers, actors, owners, the soft system, with appropriate environmental and constraint control is significant in determining the results. This is quasi-experimental research with human participation and the interpretation of social and cultural attitudes. The conceptualisation, model definition and simulation using dynamic software modelling tools, are essential to resolving the questions. The dynamic model requires credible and accuracy information to develop and choose possible scenarios, and to run the model as a simulation of reality. This construction and demolition waste stream strategy, is seen as part of the Municipal Solid Waste and Industrial Strategy.

The dynamic model is a special tool for the estimation and assessment of construction and demolition waste enabling the definition and development of strategy. It is possible to forecast construction and demolition waste production characteristics within different conditions, and defined quantitative and qualitative variables within the model. It is possible to develop scenarios forecasting results for different situations but the work demonstrates that there is a lot of research work to be done. The approach will make a significant contribution to defining strategies, that can be continually corrected by feedback from "real world" of practice.

CHAPTER 10:

SUMMARY AND CONCLUSIONS

"From Research to Reality"

(Research Center for Safety and Health 1999)

INTRODUCTION

The objective of this last Chapter is to present a summary and conclusions together with some reflections on the research developed in this thesis. The literature base has been reviewed and the state of the art and knowledge has been established. The analysis of the knowledge base has provided an holistic overview and demonstrated the need for appropriate construction and demolition methodologies generating sustainable practices. A systemic and integrated dynamic model based on systems thinking and representing the "real world" has been demonstrated.

Section 1, of Chapter 10, deals with the concept and construction of the dynamic model and of its qualitative and quantitative characteristics. The conceptualisation and definition of the model were a significant objective of this research. The model of the construction and demolition waste stream was developed as a tool for estimating and assessing the construction and demolition waste stream in the context of the sustainability agenda. It is a tool that represents a significant contribution to the development of the definition of the new Portuguese waste strategy within the terms of the European Union guidelines. During this research, it became clear that considerable work had been done on construction and demolition waste issues but there were many areas where information was absent. The greatest challenge was to obtain the base information and developed the dynamic model with a common environmental and economical strategy within the context of sustainability. The dynamic model developed will forecast construction and demolition waste stream scenarios for different goals and targets.

Section 2, of Chapter 10 presents answers to the initial research questions. Some conclusions are highlighted on the need to adopt new intellectual positions in order to move towards sustainable practices. It has been demonstrated throughout this research that the goals of sustainable construction require a new culture and different behaviour by the industry. A holistic view from construction to deconstruction is needed at each stage of the activity.

Section 3, had the objective of illuminating the way to develop a Portuguese strategy for the construction and demolition waste stream. An objective was to integrate available knowledge for the synergetic development of a construction and demolition waste framework. A sound waste management strategy will support the development of a Portuguese construction and demolition waste management Action Plan. The necessity for a programme of further research and development represents the final concerns from this research.

SECTION 1: THE DYNAMIC MODEL AND A NEW ATTITUDE AND CULTURE FOR THE FUTURE

Systems dynamics methodology using qualitative and quantitative data was use to create the model. Soft systems methodologies and systems thinking approaches contributed to the concept of the qualitative perspective and inter-relationships with their perceived relationships with the "real world". The development of the dynamic model created a tool that improved understanding of the deconstruction process and the debris trail. Other objectives of the dynamic model are the consideration of quality factors multipliers and to contribute to the estimation of quantities. How the contributions are made are dependent on the model structure adopted at the time of construction.

The work developed in the Lisbon area multiple case studies made a contribution to the qualitative variables of the model. The questionnaire developed by the working group made a significant contribution to the analysis of the quantitative data. The survey undertaken between January and August 1997 with the participation of the Lobbe Derconsa Company (Lobbe Derconsa AS 1998) played a significant role in illuminating the characteristics of the waste stream in Portugal. The case studies contributed towards a better understanding of the particular variations of the waste stream in different locations. The ADEME (1998) studies were used in a key role in providing the sources and types of waste stream to enable the development of the concepts and the structure of the dynamic model.

The inter-activity between the quantitative and qualitative data in the model is fundamental to the development of different scenarios. The model must contain specific elements to quantify targets and goals for a specific construction and demolition strategy. This issue was demonstrated by the ADEME (1998) study and it became the main support for the structure of the dynamic model. The three sources of construction and demolition waste, as well as the four Types of wastes represented in the ADEME (1998) study were used directly in the dynamic model flows of the Construction and Demolition Environmental Impact System.

It emerged from the research that new attitudes and behaviour were needed in order to deal with sustainable agenda. This was true in systems where political, institutional, social, economic and environmental issues condition the outcomes. A new culture needs to emerge to support sustainable practices in the construction industry and a new paradigm "from construction to deconstruction". This paradigm represents the new sustainable construction principles.

SECTION 2: THE ANSWERS TO THE RESEARCH QUESTIONS

The main objective of this Section is to present the answers to the initial research questions posed by this research. The questions and answers are presented below:

The first research question was:

- How can we deconstruct a building that is no longer required within the concepts of sustainability?

The answer to this first question is in two parts. The first part is concerned with maximising the recovery of resources from the redundant building. The second part is concerned with feeding the information gained from the first activity back into the building design process.

The deconstruction process occurs when renovation, rehabilitation and refurbishment are no longer possible. Obsolescence has occurred and the building is obsolete. The goal of the deconstruction process needs to be maximising the recovery of resources. The initial waste audit identified hazardous construction materials, the appropriate demolition technology and the demolition waste stream. An appropriate dismantling phase, stripping out recoverable materials, followed by selective demolition with appropriate technical solutions should drive the process. Appropriate technical solutions constitute the core of a sound deconstruction process. They are conditioned by the construction technology, time scale for the works and the safety and environmental constraints of the project. The new goals of the process need to be conveyed to all the actors involved. There is a need for information, preparation, training and the motivation of those actors.

The lessons learned from the study of the nature of deconstruction process of buildings, with respect to the needs to be fed back to the building project inception stage. It will be a long time before the feedback has practical effect but the process must begin without delay. An efficient deconstruction process must be conceived at the inception and design stage. Architects, designers, engineers and constructors must focus on the new goals and develop their approaches accordingly. The study of building Life Cycle Assessment "from cradle to grave", the implications of new materials, cleaner technologies with less energy consumption and less raw material extraction, must drive these options. The new paradigm "from construct to deconstruct" should drive the building and construction options with the all actors in industry involved and there is a need to provide design guidelines for sustainable construction.

-<u>The second research question was:</u>

What are the characteristics of the deconstruction and demolition waste stream/debris trail?

Variations in demolition processes create limitations in the characterisation of the qualitative and quantitative factors in the debris trail. From a European view this is also related to differences between the Northern and Southern countries. These differences are linked to culture, geographic and physical characteristics, climate, technologies, materials and processes. Different cultures and traditions produce different concepts and construction solutions. These differences lead to variation in the qualities and quantities of materials used in construction.

This research has followed the ADEME (1998) classification of the construction and demolition waste stream. The fieldwork was designed to separate and measure the materials before they left the site and before reusing, recycling, recovery or a final disposal to landfill. There were limitations to the exercise for a number of reasons. Appropriate training will overcome the limitations and then it will be possible to measure percentages, which would be accurate enough to represent the waste stream. The need to observe the deconstruction process at the dismantling phase the selective demolition phase and the separated material stream is essential. The use of appropriate equipment and staff training must be a priority.

<u>The third research question was:</u>

-How can the studies of the debris trail contribute towards sustainable construction objectives?

The study and the understanding of the demolition debris trail are a major element towards the achievement of sustainable construction objectives. Kibert (1994a) proposed a model of sustainable construction represented by three axes, materials, energy and ideas. The valorisation of the debris trail represents a significant step towards the goals of sustainable construction. The principles of sustainable construction are embedded in the concepts and structure of the dynamic model.

The fourth research question was:

- To what extent can the Construction and Demolition Sub-System be developed to improve our understanding of the waste stream?

The Construction and Demolition Sub-system is a sub-system within the dynamic Building + Environmental Impact System. It is the context of the construction and demolition waste stream. The dynamic model developed using systems dynamics theory permits us to simulate the "real world" activities. It illuminates and gives insight into the inter-activity and inter-relationships between the systems that constitute sustainable and integrated management (Inácio and Golton 1997). Those insights will enable the Construction and Demolition Sub-System to be developed to address the goals set.

The fifth research question was:

- To what extent can a dynamic tool for estimating and assessment be developed in order to better illustrate the relationship between the characteristics of materials in the waste stream and the nature of deconstruction process?

Dynamic tools such as the dynamic model constructed as the aim of this research consider a relationship between the nature and characteristics of construction and demolition waste materials. This dynamic relationship is affected by variables such as attitudes and behaviour, institutional conditions, environmental and economic factors and whatever else is considered relevant in this context.

The characteristics of the dynamic model with positive and negative loops, receiving feedback from practice can simulate different scenarios. It enables the assessment of the qualities and quantities the waste stream based on different assumptions. These strengths enable different alternatives or scenarios, based on policy, decisions, plans and actions to be simulated to inform strategy development. Strategy development has to be supported by dynamic software tools based on complex and dynamic relationships.

The performance of the model can be improved by better data and information fed back from the "real world" of practice. The feedback will be based on the monitoring and assessment of results of the strategy.

The development of the work done by Yost and Halstead (1996) on relationship of the permit process for construction and deconstruct and the characteristics of the waste stream in the Portuguese context would seem appropriate. The model could retain the designed structure with *per capita* population multipliers with an additional opportunity to quantify the waste stream from data based on the permit process. A comparative analysis of the results would drive the model development forward.

<u>The sixth research question was:</u>

-How to maximise the likelihood of an appropriate human environment with an emphasis on technical, scientific, economic, social and cultural aspects, where all participants are involved in implementing an integrated strategy for sustainable construction?

The research demonstrated that there was a need to educate all the actors and stakeholders in terms of the sustainability agenda. A major cultural change was needed to support a strategy that could lead the way to achieve sustainable goals and targets. To be successful the education process needs to be supported by institutional, environmental, economic and social groups.

The next Section is about the issues that need to be addressed to assist in moving towards defining a new construction and demolition strategy in Portugal.

SECTION 3: RECOMMENDATIONS FOR A CONSTRUCTION AND DEMOLITION WASTE STREAM STRATEGY IN PORTUGAL

This Section deals with the need to propose recommendations to define a strategy for construction and demolition wastes in Portugal. Those recommendations will be made in the light of the answers to the research questions that illuminated issues concerning the construction and demolition waste stream. They contribute to understanding the need for a new field strategy.

Morgan and Argus (1995) made fifty-six recommendations to the European Union to improve construction and demolition waste stream management in its Member States (Appendix K). The recommendations number forty-nine and the report illustrates this objective:

..." Member States should develop and publish detailed "Action Plans" for the implementation of the strategy for the management of construction and demolition wastes. These plans should set out:

(i) – their objectives
(ii) – their proposals for implementation of the measures proposed, and
(iii) - the programme for the implementation of the measures"

A strategy and the recommendations should be seen as an integrated "package" in order to maximise synergies and results. The European Community strategy for waste management to the year 2000 (EC 1996b) includes a hierarchy of waste management options. The primary emphasis is based on waste prevention, followed by promotion of recycling and re-use, and then by the optimisation of final disposal of waste that is not to be re-used. This approach to waste management is reinforced by the provisions of the Framework Directive on Waste (EC 1996b).

The strategy proposed by Morgan and Argus (1995) respects the hierarchical approach set out in the Community strategy, and highlights the cost effectiveness of the implementation of the measures proposed in the strategy. Portugal needs to consider a strategy for the country with emphasis on prevention, separation, treatment and markets as suggest by Morgan and Argus (1995:Part 2 – Strategy Document).

A new strategy adapted to the Portuguese reality is proposed below and is consider in five main phases. All the components of the strategy are derived from the lessons of this research and from Morgan and Argus (1995:Part 2 – Strategy Document). To achieve the objectives the strategy must have appropriate implementation, enforcement and monitoring. Table 10.1 below, adapted from Morgan and Argus (1995:Part 2 – Strategy Document: 11) summarise the various elements of the strategy for the management of construction and demolition wastes adapted to the Portuguese situation. The elements are identified together with the actions and those responsible for their implementation.

Table 10.1 – Overall strategy on construction and demolition waste stream in Portugal with five phases

1 Phase – <u>General Overview Phase</u>

ELEMENT	ACTIONS	RESPONSIBLE
Definitions	Elaborate the Portuguese Waste Catalogue for waste management planning and operational purposes	(A) Ministry of the Environment (B) Ministry of Industry and Economy
	Adopt definitions of "waste" given in Directive 75/442/EEC, and "construction and demotion waste" as given in the European Waste Catalogue.	(A)

Enforcement	Rigorous enforcement of legislation and regulations controlling the disposal of construction and demolition wastes.	(A) (B)
Information	Provide guidance to "competent authorities on data requirements	(A)
	Co-ordinated collection and dissemination of data on technology.	(A) (B)
	Co-ordinated collection and dissemination of data on legislation and planning.	(A) (B)
Monitoring	Develop detailed proposals for monitoring the implementation and outcome for the Strategy	(A)

2 Phase – Prevention Phase

ELEMENT	ACTIONS	RESPONSIBLE
Education and Information	Research, collect and disseminate data on existing and emerging best practices in waste management and the potential use of recovered materials	(A) Ministry of the Environment (B) Ministry of Industry and Economy (C) Ministry of Education
	Extend and develop education programmes with a focus on waste.	(A) (C)
Waste prevention oriented planning and design	Develop waste prevention measures and implement through waste prevention orientated design and planning.	(A) (B) (D) Ministry of Public Works and Planning
Recovery oriented construction	Development and implement recovery orientated construction measures, and the use of recovered products and materials.	(A) (B) (D)
Adapted logistics on construction sites	Adjust logistics to waste prevention and recovery.	(A) (B) (D)
Collection and Return Systems	Develop and promote collection and return systems for building and construction materials. Funding pilot schemes.	(A) (B) (D)

Life Cycle Analysis	Develop product/material environmental data sheets for construction products and materials based on LCA methodology.	(A) (B)
Increase technical and economic lifespans	Encourage maintenance and renovation of works to increase technical and economic lifespans.	(A) (B)
Qualitative prevention	Encourage use of environmentally sustainable products/materials.	

3 Phase – Separation Phase

ELEMENT	ACTIONS	RESPONSIBLE
Consistent separation of materials to be recovered	Encourage contractors to meet the qualification system for construction enterprises.	(A) (B)
	Introduce licensing and/or certification systems for contractors and Code(s) of Practice and permit systems for construction, waste transportation and demolition activities.	(A) (B)
	Contractors to seek accreditation under Quality Assurance schemes.	(A) (B)
	Improve training of contractors in good waste management practice.	(A) (B)
Improvement of output material controls	Develop guidelines and checklists for the evaluation of structures prior to demolition.	(A) (D)
Encouraging recovery (discouraging disposal)	Develop and adopt mechanisms to encourage recovery, and discourage disposal, of potentially recoverable materials.	(A) (B)
Recovery orientated separation	Develop recovered orientated separation schemes.	(A) (B)

4 Phase – Treatment Phase

ELEMENT	ACTIONS	RESPONSIBLE
Standards and Quality Assurance Systems	Adopt recognised product and material standards and implement quality assurance systems in the secondary materials recovery industry.	(A) (B) (D)
Treatment Technology	Feasibility studies on recovery systems, pilot plants for feasibility testing and demonstration.	(A) (B)
Treatment Technology (continued)	Collect and disseminate data on existing and emerging treatment technologies.	(A) (B) (C)
ELEMENT	ACTIONS	RESPONSIBLE
Legal requirements for treatment processes	Develop and implement legislation to facilitate and regulate the provision of materials recovery facilities.	(A) (B)
Performance oriented standards	Update standards, specifications, and regulatory instruments, to remove discrimination against secondary materials.	(A) (B)

5Phase – Markets Phase

ELEMENT	ACTIONS	RESPONSIBLE
Exemplary role of public organisations	Implement contract conditions to encourage good practice and use of secondary materials in publicly funded projects.	(A) (B) (D)
	Pilot projects on environmental construction activities.	(A) (B) (C)
Obtaining market transparency	Develop and implement waste management plans for construction and demolition wastes.	(A) (B)

Source: Adapted from Morgan and Argus 1995

In summary the strategy proposed should be implemented in five scheduled phases, such as: 1 – General overview phase, 2 – Prevention phase, 3 – Separation phase, 4 – Treatment phase and the 5 – Market phase. The implementation can be simulated and monitored by the dynamic systems model developed in this research and the feedback used to improve and control the process.

The next Section presents a final summary of the discussion on the issues of the construction and demolition waste stream, which justify further research and development.

SUMMARY OF MAIN DISCUSSIONS TOWARDS FURTHER RESEARCH AND DEVELOPMENT

Some constraints need to be studied from the beginning of the implementation of a strategy, as they can create difficulties in their development. The experiences of other countries for example the UK (DoE 1995b:53) show that the reuse and recycling of construction and demolition industry wastes, are constrained by some factors. These factors arise from the need for information, institutional support, economic and financial as well environmental rules, regulation, and user requirements. The areas of constraint are clearly identified in the study from the UK (DoE 1995a). They include Statutory Controls, Local Planning Policy, Feedstock, Investments in Processing, Quality Control, Environmental Concerns, Market Conditions, Standards and Specifications and Liability. These conclusions result from a pragmatic view of the "real world" and the insights provided by systems thinking.

Research and development, education and training are key issues that need to be addressed, with respect to the waste stream, in order to achieve the sustainable objectives. Morgan and Argus (1995) recommend that the Commission should set up research projects with the objectives of collecting data on, and researching available and emerging techniques in:

- waste prevention

- recovery orientated construction, and produce educational material based on its findings

Member States should also encourage the institutions, educational establishments and professional and trade associations and federations responsible for the education and training of designers and managers of building and civil engineering works, to include education and training in, and the adoption of:

- waste prevention oriented planning and design.

- recovery oriented construction.

- the use of life cycle analysis techniques to assist in the specification of materials and products.

- qualitative prevention.

- design for multiple uses; and

- design for extending the useful and economic life span of structures.

These guidelines are clear sustainable development issues. Sustainable development, or better sustainability, represents a new way of thinking in planning, designing, building, operating and maintenance infrastructure facilities, such as roads, buildings and bridges. Research and development should be developed as a need for the industry to adapt to the challenge of providing for basic human health, and comfort requirements and for economic opportunity with environmentally sustainable development (CERF 1996b).

ADEME (1998, Vol.4:95) recommended the follows areas of further research:

- The development of the construction and demolition use, needs a better knowledge of its quantities but mainly an improved knowledge of its nature and composition.

- It is fundamental to separate the wastes on construction sites, and to develop treatment adapted to their specification, in order to reduce costs of recycling and stock.

- To develop National specifications and the professional regulation of selective demolition as well as in the deconstruction process itself.

- To create the practical conditions in terms of institutional, technical and economic conditions to make feasible the reuse and recycling of construction and demolition waste stream.

The CIB Report Publication 237 (1999) also makes recommendations in this particular area of waste. They are:

. Bettering waste management (work sites and communities).

. Reducing the environmental impact of construction waste through minimisation and recycling.

. Developing water-saving devices in both new and existing buildings and systems for capturing rain water.

. Developing methodology for saving and recycling construction materials, reuse and substitution by renewable materials.

. Developing ways for an efficient use of materials (service life, system repair, improved quality of materials, components and products).

. Improving durability of coatings.

. Developing the life expectancy of indigenous construction materials and technologies.

. Upgrading performance of the existing building stock.

.Developing new technologies and systems for renovating and retrofitting.

The work developed in this research makes a contribution to the objectives expressed by these other authors. They are contained in the concepts and knowledge base in the Building + Construction Environmental Impact Systems (Inácio and Golton 1997). This model has driven this research towards the construction of a dynamic model. The dynamic construction and demolition model will give insight into the construction and demolition waste issues that need to be understood in order to achieve the goals of sustainable construction. The power of dynamic simulation will contribute to the development of an integrated waste management strategy based on the sustainability agenda.

THE BUILDING DECONSTRUCTION PROCESS AND THE DEBRIS TRAIL: TOWARDS A DYNAMIC MODEL

VOLUME 2 OF 2

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CONTENTS – VOLUME 2

Abbreviations

ADEME	Agence de l'Environment et de la Maîtrisse de l'Energie
AECOPS	Associação de Empresas de Construção Civil e Obras Públicas do Sul (Building and Civil Engineering Contractors Association)
Agenda 21	The Action Plan from the Earth Summit from 1992
BBRI	Belgium Building Research Institute
BC	British Council
BEPAC	Building Environmental Performance Assessment Criteria
BRE	Building Research Establishment
BREEAM	Building Research Establishment Environment Assessment
CAP.	*Per capita*
CARACAS	EU contaminated soils project research
CATWOE	Soft System Thinking mnemonic (Customers, Actors, Transformation process, *Weltanschauung*, Owners and Environment constraints).
CERF	Civil Engineering Research Foundation (American Society of Civil Engineers)
CESL	Consultores de Engenharia e Salubridade Lda.
C&D	Construction and Demolition
CHMR	Center for Hazardous Materials Research
CIB	Conseil Internationale du Bâtiment pour la Recherche l'etude et Documentation/International Council for Building Research Studies and Documentain
CIRIA	Construction Industry Research and Information Association
CIWMB	California Integrated Waste Management Board
CLARINET	Contaminated Land Rehabilitation Network for Environmental Technologies
CMS	Câmara Municipal de Silves (Portugal)
CML	Câmara Municipal de Lisboa (Portugal)
CSIRO	Australia's Commonwealth Scientific and Industrial Research Organisation
CSTB	Centre Scientifique du Bâtiment (Building Construction Scientific Centre)

Dec. Lei	Law Decree
DG	Director General
DGA	Direcção Geral do Ambiente (General Directorate of the Environment)
DG XI	EC Directorate General XI
DOE	Department of Energy (USA)
EC	European Commission
EEA	Environmental European Agency
EDA	European Demolition Association
EGF	Empresa Geral de Fomento (Portuguese General Foment Enterprise)
EIA	Environmental Impact Assessment
EMAS	Environmental Management and Auditing Scheme (EMAS)
EMU	European Monetary Union
EOP	Empreiteiro de Obras Públicas (Public Works Contractor)
EPA	Environmental Protection Agency
EPAC	Environmental Protection Agency Copenhagen
EPM	Environmental Preference Method
EQUER	Evaluation of Environmental Quality of Buildings
ERL	Environmental Resources Limited
ERRA	European Recycling and Recovery Association
ETCWEU	European Topic Centre for Waste European Union
EU	European Union
EUROSTAT	Environment Statistics
EVE	Environmental Value Engineering
EXPO'98	1998 Lisbon World Exposition
FEDER	Fundo Europeu de Desenvolvimento Regional (European Fund of Regional Development)
GFA	Gross Floor Area
Gj	Giga joule
GNP	Gross National Product
ICAT	Instituto de Ciências Aplicadas e Tecnologias (Applied Sciences and Technology Institute)

ICE	Institute of Civil Engineers
ICN	Instituto da Conservação da Narureza (Nature Institute Conservation)
IDE	Institute of Demolition Engineers
IDICT	Instituto de Desenvolvimento e Inspecção das Condições de Trabalho (Working Conditions and Development Inspectorate Institute)
INAG	Instituto Nacional da Água (National Water Institute)
INAMB	Instituto Nacional do Ambiente (National Environmental Institute)
INE	Instituto Nacional de Estatística (National Statistic Institute)
INETI	Instituto de Engenharia e Tecnologia Industrial (Industrial Engineering and Technology Institute)
INMG	Instituto Nacional de Metereologia e Geofísica (Natural Meteorological and Geophysical Institute)
INR	Instituto dos Resíduos (Portuguese Waste Institute)
IPAMB	Instituto de Promoção Ambiental (Ministério do Ambiente)
IPE	Institute of State Participations
IPPC	Integration Pollution Prevention Control Directive
IPTS	Institute for Prospective Technological Studies
ISO	International Standard Organisation
IST	Instituto Superior Técnico
ISWA	International Solid Waste Association
ITEC	Institut de Tecnologia de la Construcció de Catalunya (Spain)
IUCN	International Union for the Conservation of Natural Resources
Ka	Kilometer
KWh	Kilowatt hour
LCA	Life Cycle Assessment
LNEC	Laboratório Nacional de Engenharia Civil (National Civil Engineering Laboratory)
LULU	Locally Undesired Land Use
MA	Ministério do Ambiente (Ministry of the Environment)
MARN	Ministério do Ambiente e Recursos Naturais (Ministry of the Environmental and Natural Resources)

MEE	Ministry of Environment and Energy (Denmark)
MEPAT	Ministério do Equipamento Planeamento e Administração do Território (Ministry of the Equipment, Planning and Country Planning)
MHOP	Ministério da Habitação e Obras Públicas
MHSPE	Ministry of Housing Spatial Planning and Environment (The Netherlands)
MSW	Municipal Solid Waste
NEF	New Economist Foundation
NGO's	Non Governmental Associations
NICOLE	Industry contaminated land project research
NL	Netherlands
NIMBY	Not In My Backyard
OECD	Organisation for Economic and Co-operation Development
O J.	Official Journal (European Union)
PER	Planos Especiais de Realojamento (Special Reaccomodation Plans)
PERSU	Plano Estratégico de Resíduos Sólidos Urbanos (Municipal Solid Waste Strategic Plan)
POA	Programa Operacional do Ambiente (Operational Programme of the Environment)
PNPA	Projecto Nacional de Política do Ambiente (National Environmental Policy Project)
PNUD	Plano da Nações Unidas para o Desenvolvimento (United Nations Development Plan)
PPNR	Projecto de Plano Nacional de Resíduos (National Waste Project Plan)
PRISM	Preserving Resources through Integrated Sustainable Management of Waste
PSR	Pressure – State – Response
PTI	Public Technology Inc. (USA)
RICS	Royal Institute Chartered Surveyors
RILEM	International Union of Testing and Research Laboratories for Materials and Structures

RIO+5	United Nations Conference at New York five years after the Earth Summit held at Rio de Janeiro (Brazil) in 1992
SETAC	Society of Environmental Toxicology and Chemistry
SPV	Green Point Society
SSM	Soft Systems Methodology
SWANA	Solid Waste North America Association
TC	Technical Committee
TG	Task Group
UK	United Kingdom
UGT	União Geral de Trabalhadores (General Workers Union)
UN	United Nations
UNCSD	United Nations Commission for Sustainable Development
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNIDO	United Nations Industrial Development Organisation
UNITAR	Unite Nation Institute for Training and Research
UNL	Universidade Nova de Lisboa (New University of Lisbon)
UNEP	United Nations Environment Programme
UNITAR	United Nation Institute for Training and Research
UNGASS	United Nations General Assembly Special Session
UNU	United Nations University
USA	United States of America
USEPA	United States of America Environmental Agency
US	United States
USGBC	United States Green Building Council
UTL	Universidade Técnica de Lisboa
WCED	World Commission on Environment and Development
WHO	World Health Organisation
WRF	Waste Resource Foundation
WTO	Word Trade Organisation
WWF	World Wide Fund for Nature
Yr.	Year

APPENDIX A:

CATEGORIES OF WASTE (EC DIRECTIVE 91/156/CEE 18 March 1991)

APPENDIX A:

CATEGORIES OF WASTE (EC DIRECTIVE 91/156/CEE 18th MARCH)

Appendix B: Annexes I to III of Directive 91/689/EEC on hazardous wastes

ANNEX I

CATEGORIES OR GENERIC TYPES OF HAZARDOUS WASTE LISTED ACCORDING TO THEIR NATURE
OR THE ACTIVITY WHICH GENERATED THEM (*) (WASTE MAY BE LIQUID. SLUDGE OR SOLID IN FORM)

ANNEX I.A. Wastes displaying any of the properties listed in Annex III and which consist of:

1 anatomical substances; hospital and other clinical wastes;
2 pharmaceuticals, medicines and veterinary compounds;
3 wood preservatives;
4 biocides and phyto-pharmaceutical substances;
5 residue from substances employed as solvents;
6 halogenated organic substances not employed as solvents excluding inert polymerized materials;

7 tempering salts containing cyanides;
8 mineral oils and oily substances (e.g. cutting sludges, etc.);
9 oil/water, hydrocarbon/water mixtures, emulsions;
10 substances containing PCBs and/or PCTs (e.g. dielectrics etc.);
11 tarry materials arising from refining, distillation and any pyrolytic treatment (e.g. still bottoms, etc.);
12 inks, dyes, pigments, paints, lacquers, varnishes;
13 resins, latex, plasticizers, glues/adhesives;
14 chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known (e.g. Laboratory residues, etc.); pyrotechnics and other explosive materials;
16 photographic chemicals and processing materials;
17 any material contaminated with any congener of polychlorinated dibenzo-furan;
18 any material contaminated with any congener of polychlorinated dibenzo-p-dioxin.

ANNEX I.B.

Wastes which contain any of the constituents listed in Annex II and having any of the properties listed in Annex III and consisting of:

19 animal or vegetable soaps. fats, waxes;
20 non-halogenated organic substances not employed as solvents;
21 inorganic substances without metals or metal compounds;
22 ashes and/or cinders;
23 soil, sand, clay including dredging spoils;
24 non-cyanidic tempering salts;
25 metallic dust, powder;
26 pent catalyst materials;
27 liquids or sludges containing metals or metal compounds;
28 residue from pollution control operations (e.g. baghouse dusts, etc.) except (29), (30) and (33);
29 scrubber sludges;
30 sludges from water purification plants;
31 decarbonization residue;
32 ion-exchange column residue;
33 sewage sludges, untreated or unsuitable for use in agriculture;
34 residue from cleaning of tanks and/or equipment;
35 contaminated equipment;
36 contaminated containers (e.g. packaging, gas cylinders. etc.) whose contents included one or more of the constituents listed in Annex II;

37 batteries and other electrical cells;
38 vegetable oils;
39 materials resulting from selective waste collections from households and which exhibit any of the characteristics listed in Annex III;
40 any other wastes which contain any of the constituents listed in Annex II and any of the properties listed in Annex III.

APPENDIX B:

SEVENTEEN CONCLUSIONS FROM 1994 DGXI SEMINAR

APPENDIX B:

SEVENTEEN CONCLUSIONS FROM 1994 DGXI SEMINAR

Expert Seminar on Waste Management Planning

Waste Management Policy Unit - DGXI.A.4 of the
European Commission in association with
Travers Morgan Environment

Brussels – 10 th and 11 th January 1994

Summary and Conclusions

This summary, and the associated conclusions (given in boxes in the text) have been prepared four notes taken by Travers Morgan Environment at the seminar, and from transcripts made from the tape recordings of the official simultaneous interpretation in English of the proceedings of the seminar.

The conclusions reached at the seminar paid full regard to the principle of subsidiary. All proposals made can be implemented without infringing this principle.

Preparing the Plan

It was generally recognized by all delegates that reliable data on the nature, location and volume of wastes arising was a pre-requisite to the planning of a network of waste management facilities.

1 *The mapping of waste arising from all sources within an area should be a foundation of the plan or plans for that area.*

A number of delegates expressed concern that the geographic areas within which they had the responsibility to manage waste were not always fully compatible with the management requirements of particular wastes. These concerns appeared to relate to specific wastes rather than to wastes generally. Examples given of the difficulties experienced included:

the need for the provision of facilities on a larger scale, or requiring a greater investment, than was consistent with the planning authority's area of responsibility; the lack of a particular specialist knowledge at the planning authority level.

There was a general acceptance that different types of wastes required different geographical planning areas, although all the contributions made on this subject were in agreement that the detailed planning of waste management should be devolved to the most local level practicable.

2 *The geographical scale at which disposal of each particular kind of waste should be planned should be determined having regard to:*

- *i* *the volumes of the particular waste which are necessary to obtain economies of scale in the technology of treatment process, and*
- *ii* *the need to access a pool of knowledge that is sufficiently skilled in the particular kind of waste treatment.*

Where the geographical scale extends beyond the boundary of the plan-making authority, the co-operation referred to in par. 11 will be of particular importance.

There was a general agreement among delegates that it was not possible accurately to predict the future nature, volume and location of wastes arising and residues for disposal. The tactics identified as giving rise to this uncertainty included:

changes in economic circumstances (growth/recession); changes in the demand for, and nature of, consumer goods; changes in manufacturing methods; the introduction of innovative waste treatment methods; uncertainty as to the effects of policy changes (prevention, minimization, re-use, recycling).

The difficulty in accurately identifying a single future waste management strategy was generally recognized.

A number of delegates noted that their existing waste management infrastructure was not capable of accommodating significant short and medium term fluctuations in the nature and volume of waste.

There was a general recognition that large scale changes to waste management infrastructure could not be made within a short time scale. The main reasons put forward for this were:

> the consultation periods associated with achieving public acceptance of the provision of waste management infrastructure; the scale of investment required to provide environmentally sound facilities; and, construction periods.

3 *Plans need to have the flexibility to cater for changes in waste generation and changes in market demands for recovered materials. The planning process should therefore consider alternative future scenarios.*

4 *Also for reasons of flexibility, the plans themselves should provide sufficient capacity in conventional disposal methods for all waste generated within the area, so that it would be possible to handle demand over the short term (say 5 years) in the event that innovative disposal methods and policies on prevention and recovery prove less successful than anticipated.*

It was noted that, for historical reasons, the concerns of the waste management planning authorities have been concentrated on the treatment and disposal of wastes rather than on their minimization. Nevertheless there was a general acceptance that plans should give greater emphasis in the future to the need to encourage the prevention and recovery of waste, and its potential for beneficial uses i.e. energy generation from incineration.

A number of delegates advocated the use of economic instruments as a tool to encourage the prevention, minimization and recycling of wastes.

5 *In practice, a major part of the content of plans will be concerned with the handling and treatment of waste arising. However plans also need to give express attention to policies and practices which encourage the prevention and recovery of waste and the use of waste for energy. Plans should include consideration of the use of pricing mechanisms that reflect the environmental impact of waste disposal, and thus act to promote waste reduction.*

A number of delegates expressed concern regarding targets for waste prevention and reduction. These concerns included:

> the setting of targets for recycled materials for which there was no established market; the setting of long term goals which, at the present time, appear only be achievable through the application of innovative treatments; a failure to define clearly the terms adopted in waste management proposals.

6 *Quantitative policy goals for waste prevention and reduction should be clearly and carefully defined, and insofar as they refer to the short term (say 5 years), the goals should be shown to be compatible with current industrial processes.*

There was a general acceptance that there needed to be greater emphasis in the future to the encouragement of the prevention and recovery of waste through the adoption of clean technology in waste generating industries. A number of delegates observed that the necessary expertise was unlike to be found in waste management planning authorities, since this involved a detailed knowledge of industrial and manufacturing process design.

Examples were given by some delegates of how advice on clean technologies was made available to industry from other governmental departments through waste management planning agencies.

7 *In the matter of waste prevention and recovery, plans should refer to the provision of governmental advice to industry on clean technology, whether this is provided by the plan-making authority itself or by other national or local agencies in the Member State.*

Social Acceptance

There was general agreement that waste management facilities could only be provided if the public accepted there was a need for them. It was recognized that with the widely differing cultural expectations and political organization of the Member States there was no single model as to how social acceptance could be achieved.

8 *The planning process aims to secure social acceptance of waste policy in general and of disposal installations in particular. To this end, it is appropriate for plan preparation to be entrusted to different levels of the administration in different Member States, reflecting cultural expectations and political organization.*

A number of delegates observed that public opposition to the provision of waste management facilities was often the single most significant obstacle to be overcome in the provision of facilities.

Accordingly these delegates stressed that the waste management planning process should involve, and be seen to involve, some democratic process whereby representations made by the public and other interested organizations could be addressed.

It was generally agreed that the planning process should also include the provision of information to the public on waste management policies, and the need and justification for facilities.

9 *The plan-making process needs to include full consultation with the public, waste producers and the waste management industry. Consultation should be preceded by the provision of ample information, and n should take place in relation both to policy and to the provision of disposal installations. The consultation process should afford opportunities to both individuals and organizations to make representations to the plan-making authority.*

There was considerable discussion on the mechanisms by which social acceptance for waste management facilities could be achieved. A number of delegates outlined an approach which they felt was able to achieve this. This involved a two stage process as follows:

Stage 1

the development of the basic general principles and policies of waste management and associated site location and environmental protection criteria; the establishment of waste arising, the facilities required to treat or dispose of them, and the general geographic areas were facilities will be required; the dissemination of information and consultation on the above.

Stage 2

the development of site specific proposals based on the outcome of the Stage 1 investigations and consultations; public consultation on the site-specific proposals only (not on the principles previously established in Stage 1).

10 *To ensure that the waste management planning process is we understood, an approach that commends itself is that consultation should take place in stages. Thus proposals for waste management policy, and the general intentions for provision of disposal installations, would be subject to consultation and decision before site-specific proposals were formulated. Site-specific consultation would take place at a later stage.*

Co-operation

It was generally accepted that the most efficient and cost effective waste management infrastructure would be provided on the basis of the needs of the waste management industry irrespective of administrative boundaries, whether municipal, regional or national.

Nevertheless it was recognized that there are significant differences in cultural expectations, administrative arrangements and legislation between and within Member States. Accordingly the objective of efficient and cost effective waste management will only be achieved if there is close practical co-operation between adjacent plan-making authorities irrespective of administrative boundaries.

11 *Practical co-operation between plan-making authorities in adjoining regions should be a high priority. Solidarity among Member States, in protecting the environment throughout the Community, means that such co-operation is as important between adjacent areas in neighboring States as it is between areas within a single State.*

Examples were given by some delegates of situations where planning authorities had found that the existing or planned waste management infrastructure had been found to be unable to meet the demands placed on it by wastes arising in neighboring areas.

Some delegates foresaw the potential for similar situations arising in their area in the future as a result of the policies adopted by neighboring authorities. The examples given generally related to wastes being exported from one area and utilizing capacity allocated for other purposes in another area.

Concern was expressed by some delegates that the environmental effects associated with the import and export of wastes, and their subsequent treatment and disposal, were not always fully addressed by the waste planning authority where the wastes originated.

12 *Each plan-making authority should consult their neighbors as to their needs and intentions, and exchange available information on waste. Legislative and administrative differences have to be fully recognized, but plans for adjoining administrative areas should be complementary to one another, to the greatest extent that is practically possible.*

Implementing Plans

It was noted that, as a general rule, the full waste management planning process was carried out to a comparatively long term cycle. Nevertheless, it was generally accepted that more frequent and routine monitoring of waste arising, and interim reviews of the implementation of the plan, were necessary if satisfactory management of waste was to be achieved.

An example was given where the required duration of the waste management plan was 12 years, interim reviews were required every 4 years, and waste arising were mapped annually.

13 *The mapping of waste arising should be updated frequently for the purpose of monitoring and reporting progress in improving waste management.*

A number of delegates emphasized that waste management plans should be more than just 'paper' plans. To this end they should contain realistically achievable aims, and the plan-making authorities should have the duty to monitor the implementation of the plans. Where appropriate the plan-making authority should have the powers to secure the implementation of the plans.

These duties and powers were seen by delegates from plan-making authorities as being an essential tool in achieving the planned objectives as they removed uncertainty for waste producers and transporters as to the enforcement of regulations.

14 *Plan-making authorities should have the duty of monitoring how plans are being implemented and should have powers to secure that waste is managed generally in accordance with the plans.*

There was some discussion regarding the differing administrative and legal arrangements adopted in Member States for the licensing of waste producers, transporters and disposes. It was accepted that, for efficient and effective waste management, these administrative arrangements must be consistent with the provisions of waste management plans at all levels, and vice versa.

15 *The system for licensing waste producers, transporters and disposes must be consistent with the waste management plan. Therefore, where the plan-making authority is not itself responsible for licensing, then either*

- *i the plan should be consistent with the licensing scheme of any higher level of government, or*
- *ii the plan should define the licensing framework to be followed by any lower level of government.*

A number of options for the provision, management and operation of waste management facilities were discussed during the seminar, and in particular the respective roles of the public and private sector.

Delegates concluded that, while there were differing cultural expectations in different Member States, there was no evidence to suggest there were any practical differences in the ability of either sector to fund effectively, provide or operate waste management facilities.

16 *Whether waste management operations are funded and undertaken by the private or public sectors is entirely a matter for the particular circumstances in each Member State.*

Support from the Commission

It was clear from comments made by the delegates, and from the questions raised during the discussions, that there was a wealth of knowledge available, and a desire on the part of all participants to learn from the experience of others.

Furthermore, throughout the seminar, and in the informal contacts between the formal presentations and discussions, it was apparent that delegates were taking full advantage of the opportunity to exchange experiences and views.

In the formal sessions, a number of delegates commented on the benefit they had derived from the seminar, and on the value of other similar forums and studies organized by the Commission.

17 *The Commission should continue to facilitate exchanges of information on the technologies of prevention, recovery and disposal and on the development of the network of hazardous waste disposal installations.*

APPENDIX C:

"ALVARÁ" LICENCE EXAMPLES

MINISTÉRIO DAS OBRAS PÚBLICAS TRANSPORTES E COMUNICAÇÕES

SECRETARIA DE ESTADO DAS OBRAS PÚBLICAS

CONSELHO DE MERCADOS DE OBRAS PÚBLICAS E PARTICULARES

COMISSÃO DE ALVARÁS DE EMPRESAS DE OBRAS PÚBLICAS E PARTICULARES

ALVARÁ DE EMPREITEIRO DE OBRAS PÚBLICAS

N.º 3642 - EOP

Empresa inscrita em 17.12.1987

MARQUES INACIO, S.A.

RUA GONCALVES CRESPO, LOTE 3 - R/C DTO.

CARCAVELOS - CASCAIS

Válido até 31 Dezembro 1992

AUT	CATEGORIA		SUBCATEGORIA	CLASSE
1		1		
2		2	Edifícios	5
3	1	3		
4		4	Estruturas de betão armado ou pré-esforçado	5
5	EDIFICIOS	5		
6		6		
7	E	7		
8		8		
9	MONUMENTOS	9	Demolições	2
10		10		
11		11		
12		12	Trabalhos de alvenarias, rebocos e assentamento de cantarias	5
13		13		
14		14	Limpeza e conservação de edifícios	3
15		15	Equipamento a incorporar em edifícios, não incluído em subcategorias específicas	3
16	2	1		
17		2	Estradas, caminhos de ferro e aérodromos	4
18	VIAS	3		
19		4	Pontes de betão armado ou pré-esforçado	3
20	DE	5		
21		6		
22	COMUNICAÇÃO	7		
23		8		
24	E	9		
25		10		
26	OBRAS	11	Parques e ajardinamentos	2
27		12	Arruamentos em zonas urbanas	5
28	DE	13	Saneamento básico	5
29		14	Equipamento rodoviário (não inclui equipamento de apoio)	2
30	URBANIZAÇÃO	15		
31		16		
32		1		
33	3	2		
34		3		
35	OBRAS	4		
36		5		
37	HIDRAULICAS	6		
38		7		
39		8		
40		1		
41	4	2	Canalizações, água e esgotos em edifícios, gás, ar comprimido, vácuo e respectivos dispositivos	2
42		3		
43	INSTALAÇÕES	4		
44		5		
45	ESPECIAIS	6		
46		7		
47		8		
48		9		

13

APPENDIX D:

LISBON AREA MULTIPLE CASE STUDIES PROTOCOL

APPENDIX D:

LISBON AREA MULTIPLE CASE STUDIES PROTOCOL

PROTOCOL

Between:

INR - Instituto de Residuos, with head otfice at Av. Gago Coutinho, 30, 1000 Lisbon, holder of corporate body identity card N° 600020690, represented by the President of the Institute, Prof. Dr. Antonio Lobato Faria;

CML - Lisbon Municipal Council, with head office at Praça do Municipio, 1100 Lisbon, holder of corporate body identity card N° 500051070, represented by the Council Alderman for the Environment and Green Spaces, Eng. Rui Manuel Carvalho Godinho;

ICAT - Instituto de Ciencia Aplicada e Tecnologia da Faculdade de Ciencias de Lisboa (University of Applied Science and Technolgy) with head office at Campo Grande, holder of corporate body identity card N° 502185767, represented by two members of the Board, Prof. Dr. Luisa Maria Abrantes and Dr. Carlos Sousa Reis;

This protocol is hereby drawn up, to be subject to the following clauses:

FIRST

1. OBJECTIVES

The proper management of a modern city depends strategically upon guidelines which result from data to be collected, studied and processed.

In order to carry out this proper management, as considered in the report of the World Committee for Environment and Development known as the Brundtland Report, the following, among other points, should be considered:

- since the reserves of raw materials are finite, the flow of substances throughout several stages of processing, consumption and use should be managed in such a manner so as to facilitate or encourage the optimisation of re-use and recycling, thus avoiding waste and the exhaustion of the reserves of natural resources;

- production and consumption of power should be rationalised;
- the patterns of consumption and behaviour of society itself should be altered.

With these points in mind, it becomes necessary to minimise waste and incentive re-utilisation and the recycling process. The need for a Sustainable Construction also means the need to classify in a suitable manner all waste, not only during the building process but also in the process of demolitions and other types of interventions such as remodelling and urban rehabilitation.

The purpose of this protocol is to make a quantitative and qualitative characterisation of the flow of waste from Constructions and Demolitions (C&D) in the Municipality of Lisbon. This characterisation should be accompanied by the characterisation of the deconstruction process, which includes the stages of dismantling and demolition properly speaking.

During the first stage, by classifying the buildings in Lisbon according to type, the study shall consider demolitions and urban rehabilitation, and it is foreseen that a second stage will follow, concerned with wastes from the construction of buildings.

SECOND

2. SCOPE

The geographical area where the work will be carried out is the Municipality of Lisbon.

The work to be carried out will follow the study mentioned above, under the heading of "Study for the Treatment of Waste from Civil Construction in the Lisbon Area" and requested by the Lisbon Municipal Council.

With this in mind, constructively homogenous areas will be privileged, from which the representative samples to be treated will be taken, bearing in mind the four types of buildings in accordance with their structural characteristics, presented by Cabrita, Aguiar and Appleton (1993), in the study carried out by the LNEC - Laboratorio Nacional de Engenharia Civil (Civil Engineering Laboratory) for the Lisbon Municipal Council in 1993. The four types of buildings are as follows:

- Type 1: before the 1755 earthquake;
- Type 2: buildings of supporting masonry of the Pombaline period (from 1755 to the third quarter of the 19th century);
- Type 3: buildings of supporting masonry of the "cage" type (3rd quarter of the 19th l century up to 1930)
- Type 4: reinforced concrete in buildings (from 1930 up till now).

Special attention will be given to the aspects concerning re-utilisation, in secondary markets, of the materials from dismantling/demolition processes; the measures required to set up this strategy will also be proposed.

The period of intervention as regards the first stage will last four months, for works in the field, which will take place between March and June 1998. The second stage will occur between July and December of the same year.

THIRD

3. PARTICIPATION:

In co-operation with the ICAT, the INR will be in charge of the technical and administrative management of the project. The ICAT will also be in charge of handling the scientific and financial co-ordination.

Besides participating in the technical co-ordination, the CML will be responsible for indicating and supplying the samples, data regarding works under way in Lisbon and the respective contact with the owners of the selected undertakings. They will also be responsible for indicating the waste circuit and consequent logistic support, with special attention to the aspects regarding the separate weighing of the different materials of which the waste consists.

FOUR

4. DESCRIPTION OF THE PROJECT:

4.1 The project refers to the qualitative and quantitative characterisation of the waste resulting from de-construction (dismantling and demolition) of the buildings of each of the structural types defined in the CML/LNEC study of 1993 and distributed throughout the homogenous areas defined in the "Study for the Treatment of Waste from Civil Construction in the area of Lisbon".

4.2. The characterisation mentioned in 4.1. will be preferably made at the site of the undertaking, at the source and should be accompanied by an analysis of the de-construction process.

4.3. For each situation there should be a De-Construction Plan, drawn up by the co-ordinating group formed by the INR, CML, ICAT, following the technical data and others supplied by the CML, in which the stages of dismantling and selective demolition are clearly defined, with special attention to the technical and logistic aspects, terms, technical specifications, procedures, regulations and obligations.

4.4. Before the interventions occur, there should be a preparatory Seminar for training and information as to objectives, scheduled and organised by the co-ordinating group, which the different parties (CML, INR, ICAT, contractors in the deconstruction process, the company collecting waste and work teams) should attend. Before taking part in the undertaking an audit of the waste should be carried out by members of the work team appointed by the co-ordinating group.

4.5. The work in the undertaking should follow the Deconstruction Plan, taking as a basic rule the maximum re-use and recycling of the materials resulting from deconstruction. This attitude implies selecting as much as possible of the materials at their source. The dismantling stage will endeavour to recover materials of roofing, wooden and metallic structures, doors and windows, decorations of bays, iron mongery and other materials which call be re-utilised.

The removal of contaminated materials such as asbestos, certain types of paint and varnishes should undergo careful attention and take place before the demolition stage, being taken away to an appropriate destination.

The sequence of the dismantling and demolition process should follow the reverse order of the building process, since this the basic rule to be followed in terms of selective demolition.

During the process of selective demolition, whenever possible at the site, materials should be separated into containers for concrete, brick masonry, and also separated, whenever possible at the site, wood, metals, stone masonry, paper and cardboard and plastic materials. Whenever it is not possible to effect separation at the site, this will be carefully done at a spot appointed by the CML for this purpose and for the respective weighing process.

4.6. The characterisation of the selective demolition process should take into account the following technical characteristics:

- characterisation of the general term of the contractor- or contractors involved in the demolition process;
- type of demolition process followed and characteristics of the respective equipment;
- characteristics of the person involved in the process of selective demolition and respective technical and professional training;
- observance of the Plan for De-Construction works.

4.7. Careful attention should be given to collecting and registering data on proper and suitable forms and in accordance with rules previously defined. These forms will be elaborated by the co-ordinating group and shall be distributed by the INR to the member of the work team who shall effect daily visits to the site to fill in same. The registration forms should indicate:

- site of the undertaking (work may be public or municipal);
- clay of registration
- number of containers installed for the different materials
- date and time for removal of containers
- transportation of any other wastes to the place for separation and weighing purposes
- the equipment on the site and the number of the contractor's workers, by categories
- the registry of photographs taken and films made and the most important aspects in accordance with the De-Construction Plan
- the registration of the materials referring to the dismantling process
- quantitative and qualitative description of the materials
- registration of contaminated materials

4.8. The work team will consist of an adequate number of persons previously made aware, informed and prepared for the objectives and general aspects of the project, and will be chosen by the co-ordinating group. The supervisor of the team will be all expert with proper training also chosen by the co-ordinating group to ensure the tasks shown in this protocol.

4.9. The forms for the control of the interventions will be collected by the supervisor of the work team and delivered weekly to the ICAT for treatment of data and complementary actions. He will prepare weekly reports to which he shall attach a form with data collected, elaborated by the members of the work teams.

4.10. The co-ordinating group shall meet at least once a month to follow and assess the results of the intervention. Any situations which may require an urgent or immediate resolution should be passed on by the supervisor to the member of the work group appointed to accompany the intervention. The co-ordinating group shall be in charge of this appointment.

4.11. Every month the co-ordinating group will analyse the results of this project, and the ICAT shall hand in the final report within a fortnight after the global intervention has ended.

4.12. The technical rules regarding the second stage will be described after the final report for the first stage has been delivered.

FIFTH

5. MANAGEMENT OF THE PROJECT:

The global management of the project shall be the responsibility of the INR, in collaboration and co-operation with the other Parties signing this protocol.

5.1. All the Parties hereto will be informed of the partial results which are obtained monthly, as well as the weekly results elaborated by the supervisor. The reports shall be presented every month to the Co-ordinating Group.

5.2. Co-ordinating Group

The Co-ordinating Group shall act as a consultant, and shall meet whenever required by convocation of the co-ordinator of any of the other members. At least one meeting should take place every month and shall consist of the following members:

a) INR representative
b) CML representative
c) ICAT representative
d) Work team supervisor

The co-ordination meetings shall take place at facilities granted by the CML, which shall also function to back up the work of the teams and supervisor.

SIXTH

6. FINANCING PROCEDURE

6.1. The financing of the actions of the project shall be guaranteed by the INR, the figures for 1997 having been 2,808,000$00 and in 1998, 3,042,000$00, including IVA.

6.2. The Lisbon Municipal Council will guarantee the actions regarding logistic support and all information and attendance of the work mentioned in this protocol.

SEVENTH

7. COMMUNICATION

7.1. All external communication regarding the Project should contain the logos of the INR, CML and ICAT.

EIGHTH

8. FINAL PROVISIONS

8.1. This protocol shall become effective upon the respective signature, ending at the end of December 1998.

8.2. This protocol shall not be extended automatically. The Signing Parties shall meet sufficiently in advance to decide as to its extension or otherwise, bearing in mind the need to conclude the work of characterisation of the wastes from construction.

8.3. This Protocol may be altered by means of all Agreement between the Parties, formalised through one of the following procedures:

a) signature of an Additional Protocol by all Parties hereto
b) Approval by all Parties hereto by simply sending registered letters

8.4. This Protocol may be ended before the term mentioned in 8.1. under the following circumstances.

a) Agreement between the Parties b) Rescission by one of the Parties, based on non-compliance with the present Protocol c) Rescission by one of the parties, with or without grounds.

8.4.1. In the case mentioned in -sub-paragraph a) of the foregoing point, the Agreement shall specify all patrimonial, financial or other implications of the recession.

8.4.2. The non-compliance of this protocol shall be invoked by means of a registered letter addressed to all the Parties and shall be considered as accepted if the Party in default should admit the fact or say nothing, by means of a registered letter, within 20 workdays.

8.5. This Protocol is subject to Portuguese law. Cases not mentioned therein shall be settled by agreement between the Parties.

8.6. This protocol shall be signed by the legal representatives or by those authorised by the Parties hereto. Representatives shall present proof of their legal capacity.

NINTH

9. METHODS OF PAYMENT
The payment referring to the first stage shall be made at the time of signing the protocol, and of the second stage after delivering the final report regal-ding the first stage.

Lisbon, November 26, 1997

On behalf of the Instituto dos Residuos

Prof. Dr. Antonio Lobato de Faria
President of the Instituto dos Residuos

On behalf of the Lisbon Municipal Council

Eng. Rui Manuel Carvalho Godinho
Alderman of the Council for Environment and Green Spaces

On behalf of the Instituto de Ciencia Aplicada e Tecnologia

Dr. Carlos Sousa Reis
Administrator

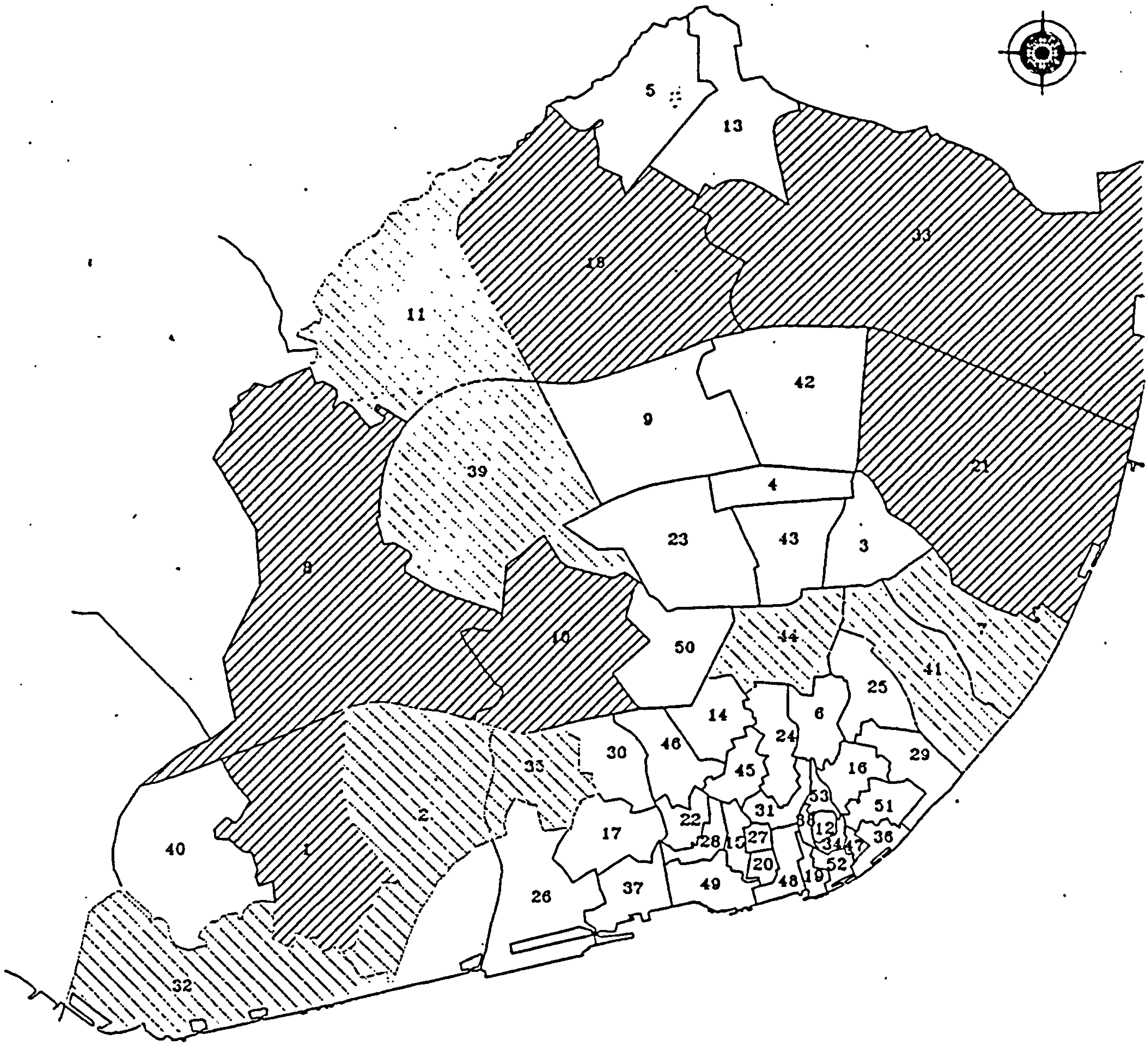
Prof. Dr. Luisa Maria Abrantes
Administrator

APPENDIX E:

LISBON MAP CIVIL PARISH DISTRIBUTION

MISSING

PRINT



OF BUILDINGS

Nº ~~de edifícios~~

>3000 | 1500 a 3000 | <1500

civil parish in

~~Freguesias de~~ Lisboa

1 - Ajuda
2 - Alcantara
3 - Alto do Pina
4 - Alvalade
5 - Ameixoeira
6 - Anjos
7 - Beato
8 - Benfica
9 - Campo Grande
10 - Campolide
11 - Carnide
12 - Castelo
13 - Charneca
14 - Coracao de Jesus
15 - Encarnacao
16 - Graca
17 - Lapa
18 - Lumiar
19 - Madalena
20 - Martires
21 - Marvila
22 - Merces
23 - N. Sra. de Fatima
24 - Pena
25 - Penha de Franca
26 - Prazeres
27 - Sacramento
28 - Santa Catarina
29 - Santa Engracia
30 - Santa Isabel
31 - Santa Justa
32 - Santa Maria de Belem
33 - Santa Maria dos Olivais
34 - Santiago
35 - Santo Condestavel
36 - Santo Estevao
37 - Santos-o-Velho
38 - Sao Cristovao e Sao Lourenco
39 - Sao Domingos de Benfica
40 - Sao Francisco Xavier
41 - Sao Joao
42 - Sao Joao de Brito
43 - Sao Joao de Deus
44 - Sao Jorge de Arroios
45 - Sao Jose
46 - Sao Mamede
47 - Sao Miguel
48 - Sao Nicolau
49 - Sao Paulo
50 - Sao Sebastiao da Pedreira
51 - Sao Vicente de Fora
52 - Se
53 - Socorro

FIGURA 3.1

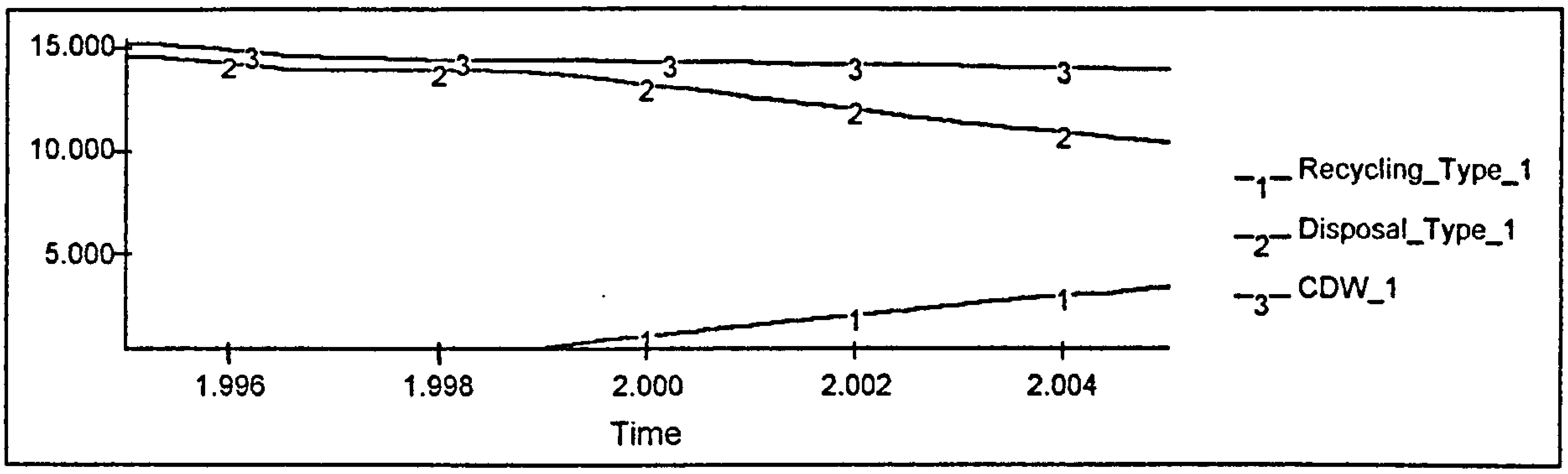
~~Distribuição do nº de~~ edifícios ~~existentes~~ por freguesia

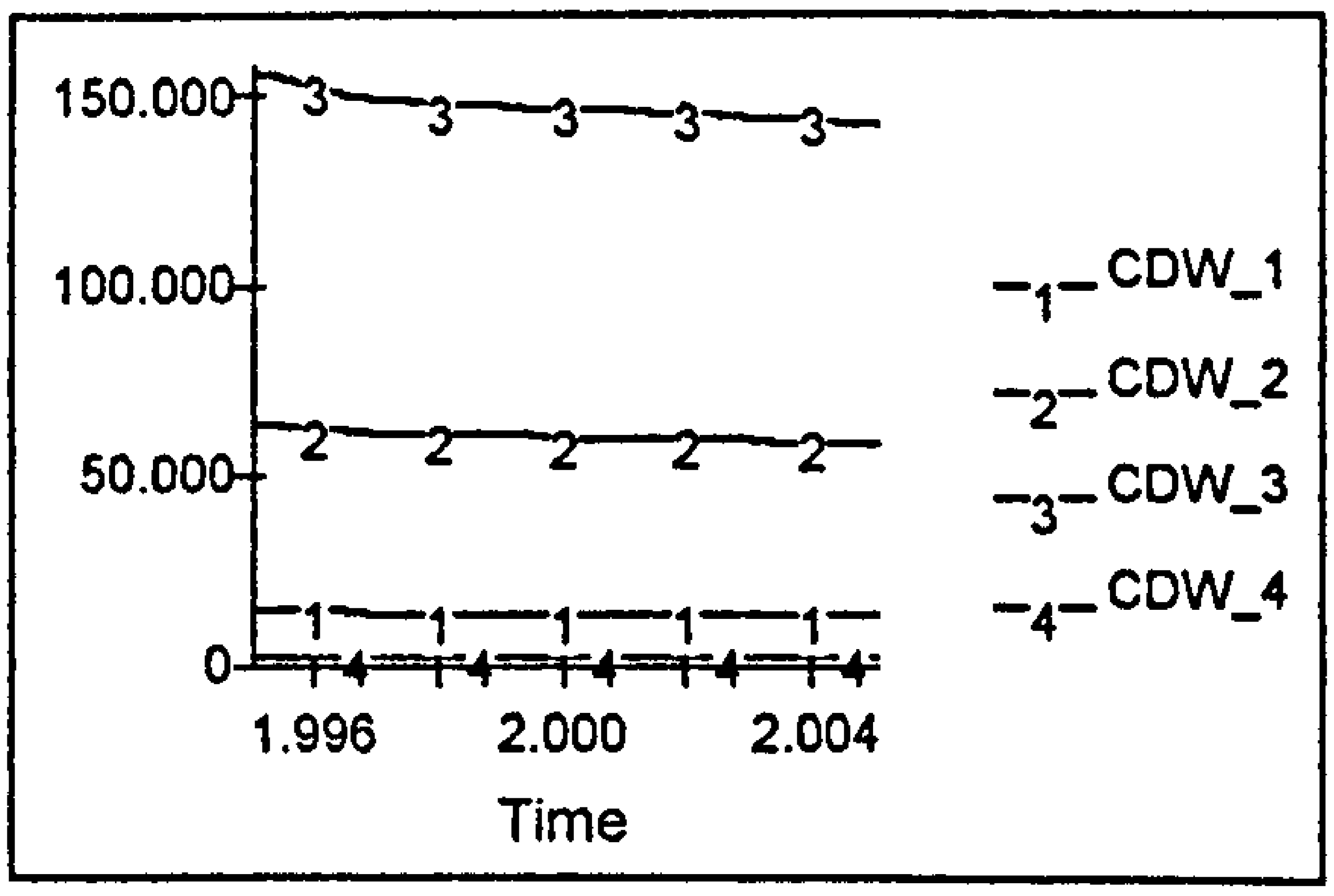
na cidade de Lisboa ... 1991

36400\FIG3_1

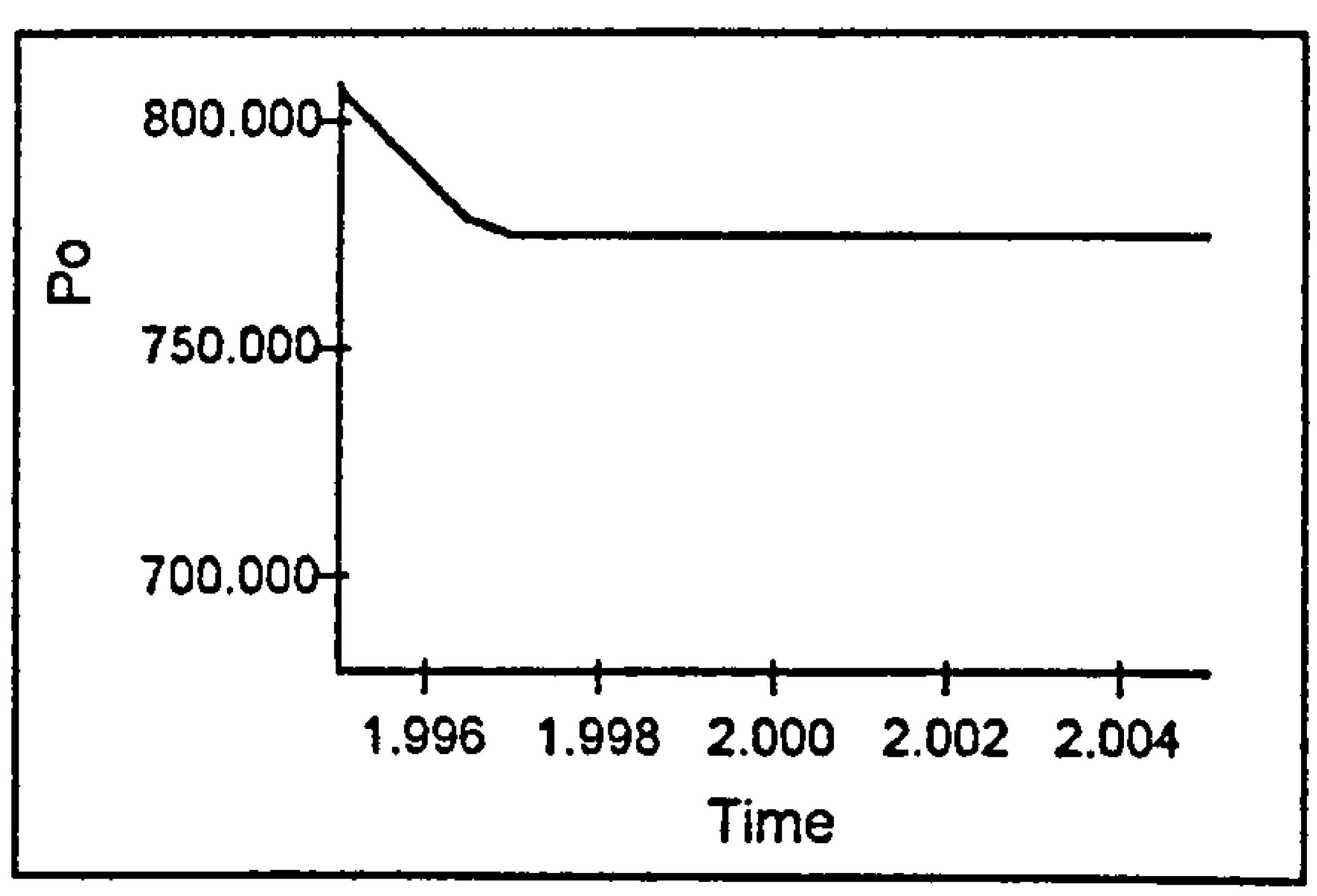
APPENDIX F:

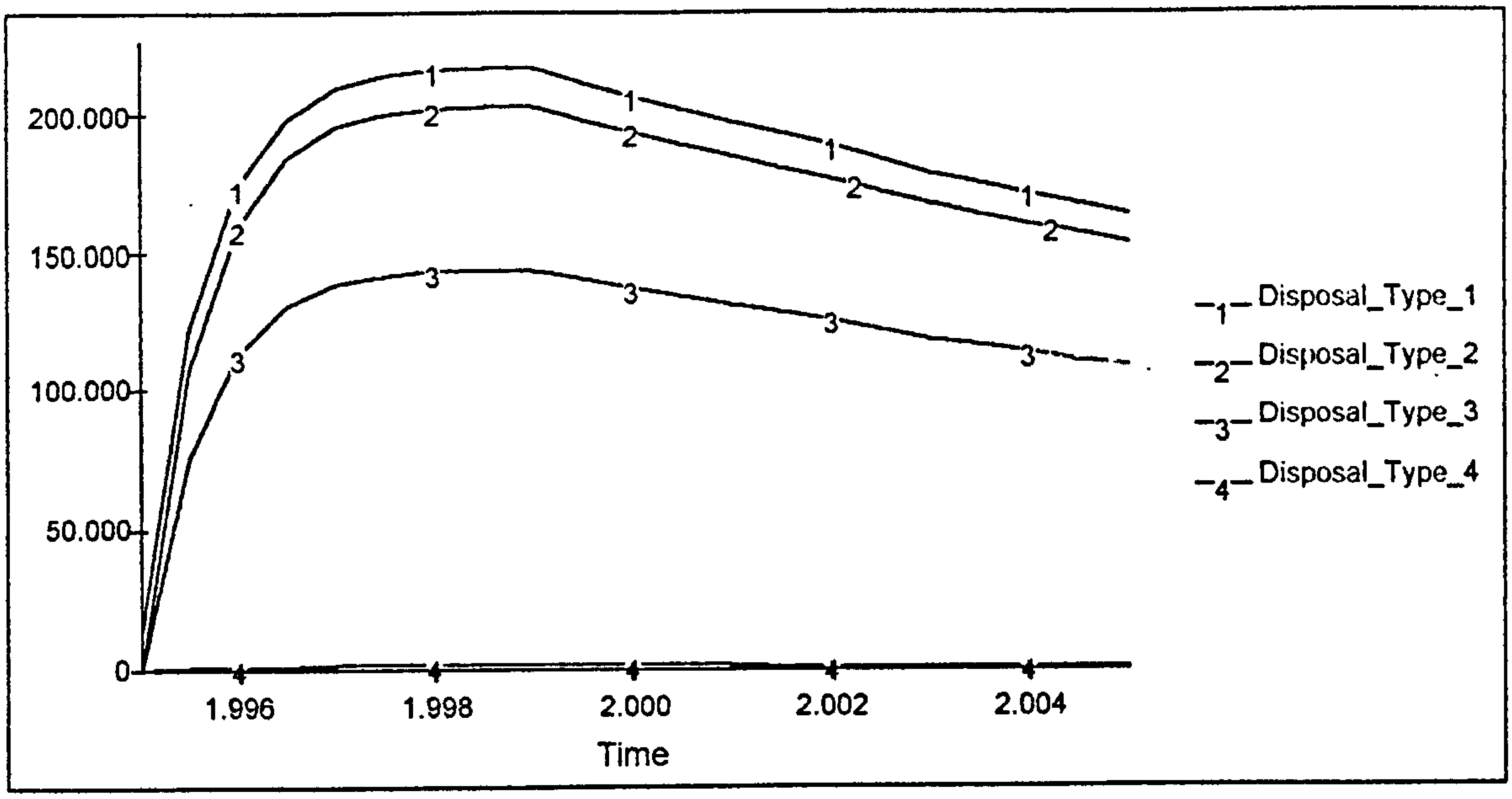
DYNAMIC SCENARIOS DEVELOPMENT

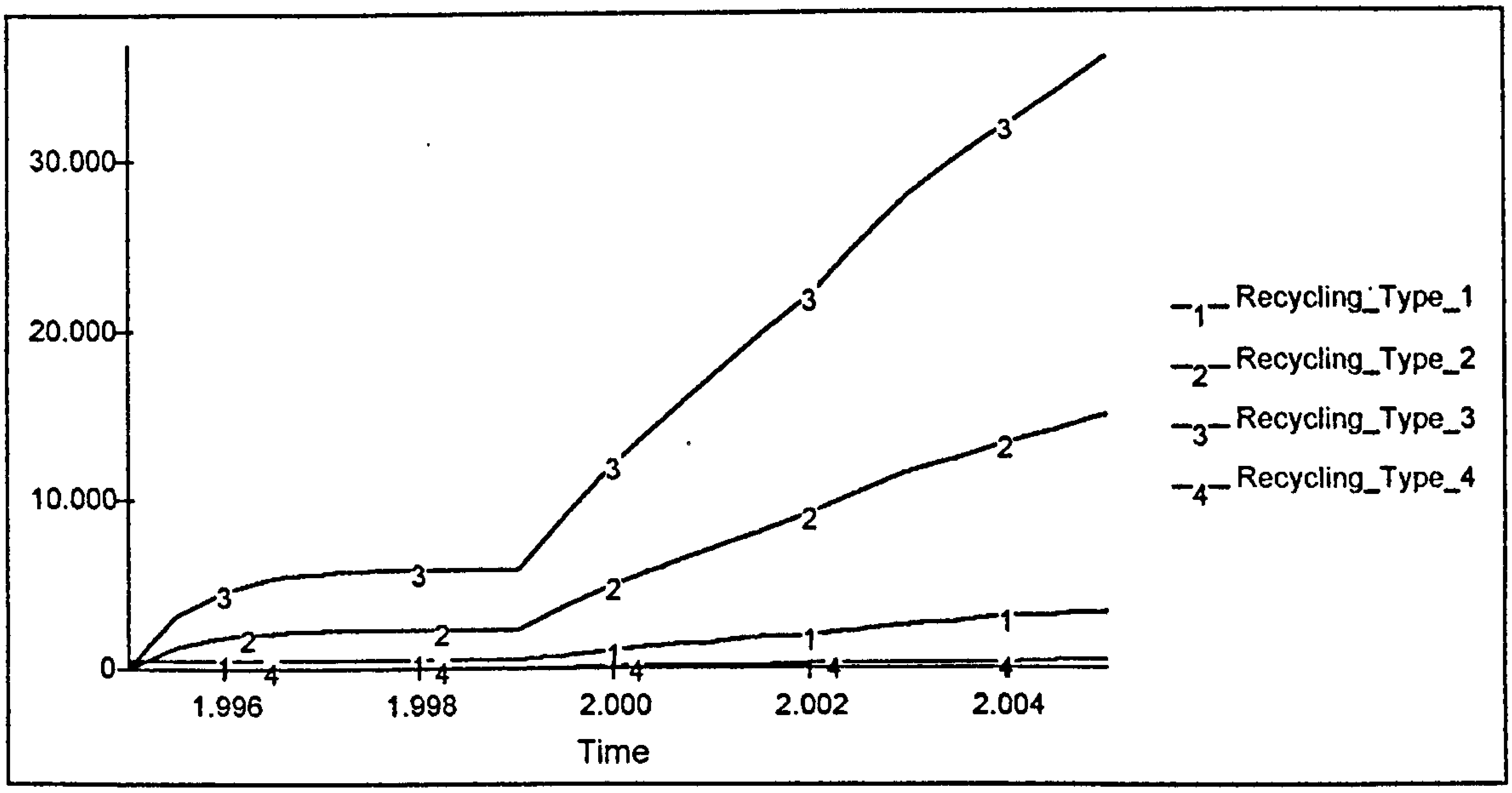

15.000
10.000
5.000
1.996
1.998
2.000
2.002
2.004
Time
Recycling_Type_1
Disposal_Type_1
CDW_1


150.000
100.000
50.000
0
1.996
2.000
2.004
Time
CDW_1
CDW_2
CDW_3
CDW_4

Time	Disposal_Type_1	Disposal_Type_2	Disposal_Type_3	Disposal_Type_4
1.995,0	14.757,57	0,00	0,00	0,00
1.995,5	14.546,58	31.348,92	75.796,28	1.081,89
1.996,0	14.340,06	46.575,19	112.610,78	1.607,37
1.996,5	14.137,97	53.749,62	129.957,29	1.854,96
1.997,0	14.019,54	56.907,54	137.592,60	1.963,95
1.997,5	13.984,13	58.234,92	140.801,97	2.009,76
1.998,0	13 948,73	58.823,40	142.224,83	2.030,07
1.998,5	13.913,33	59.042,44	142.754,42	2.037,63
1.999,0	13.877,93	59.076,75	142.837,38	2.038,81
1.999,5	13.539,72	57.727,67	139.575,54	1.992,25
2.000,0	13.203,06	56.336,97	136.213,06	1.944,26
2.000,5	12.918,16	55.143,58	133.327,65	1.903,07
2.001,0	12.634,55	53.944,21	130.427,78	1.861,68
2.001,5	12.359,36	52.775,17	127.601,25	1.821,34
2.002,0	12.085,43	51.608,70	124.780,93	1.781,08
2.002,5	11.763,07	50.234,00	121.457,13	1.733,64
2.003,0	11.442,21	48.865,04	118.147,23	1.686,39
2.003,5	11.207,61	47.864,11	115.727,15	1.651,85
2.004,0	10.974,08	46.867,56	113.317,66	1.617,46
2.004,5	10.741,62	45.875,48	110.918,98	1.583,22
2.005,0	10.510,23	44.887,90	108.531,19	1.549,14




200.000
150.000
100.000
50.000
0
1.996
1.998
2.000
2.002
2.004
Time
Disposal_Type_1
Disposal_Type_2
Disposal_Type_3
Disposal_Type_4


30.000
20.000
10.000
0
1.996
1.998
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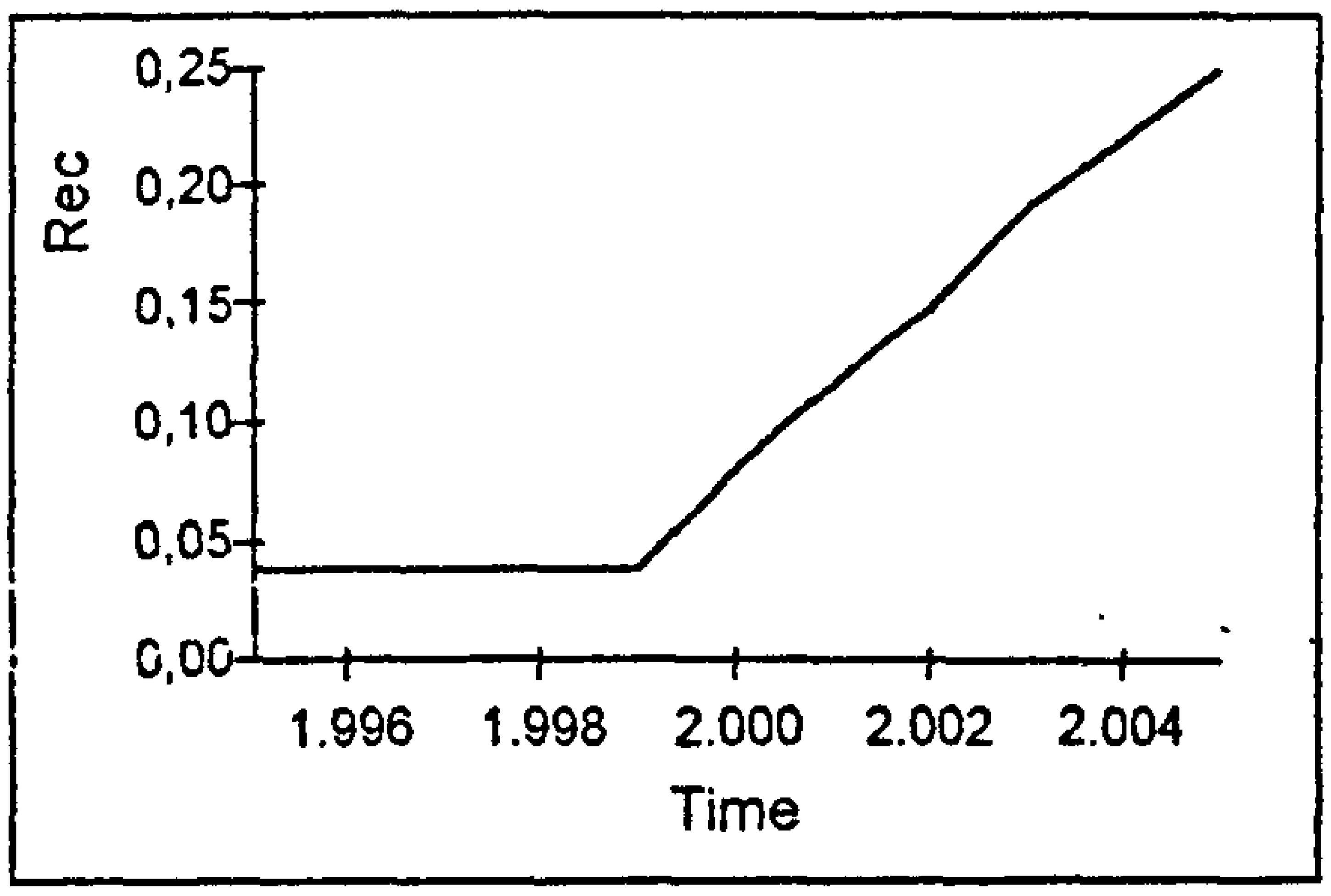
2.002
2.004
Time
Recycling_Type_1
Recycling_Type_2
Recycling_Type_3
Recycling_Type_4


Rec
0,25
0,20
0,15
0,10
0,05
0,00
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1.998
2.000
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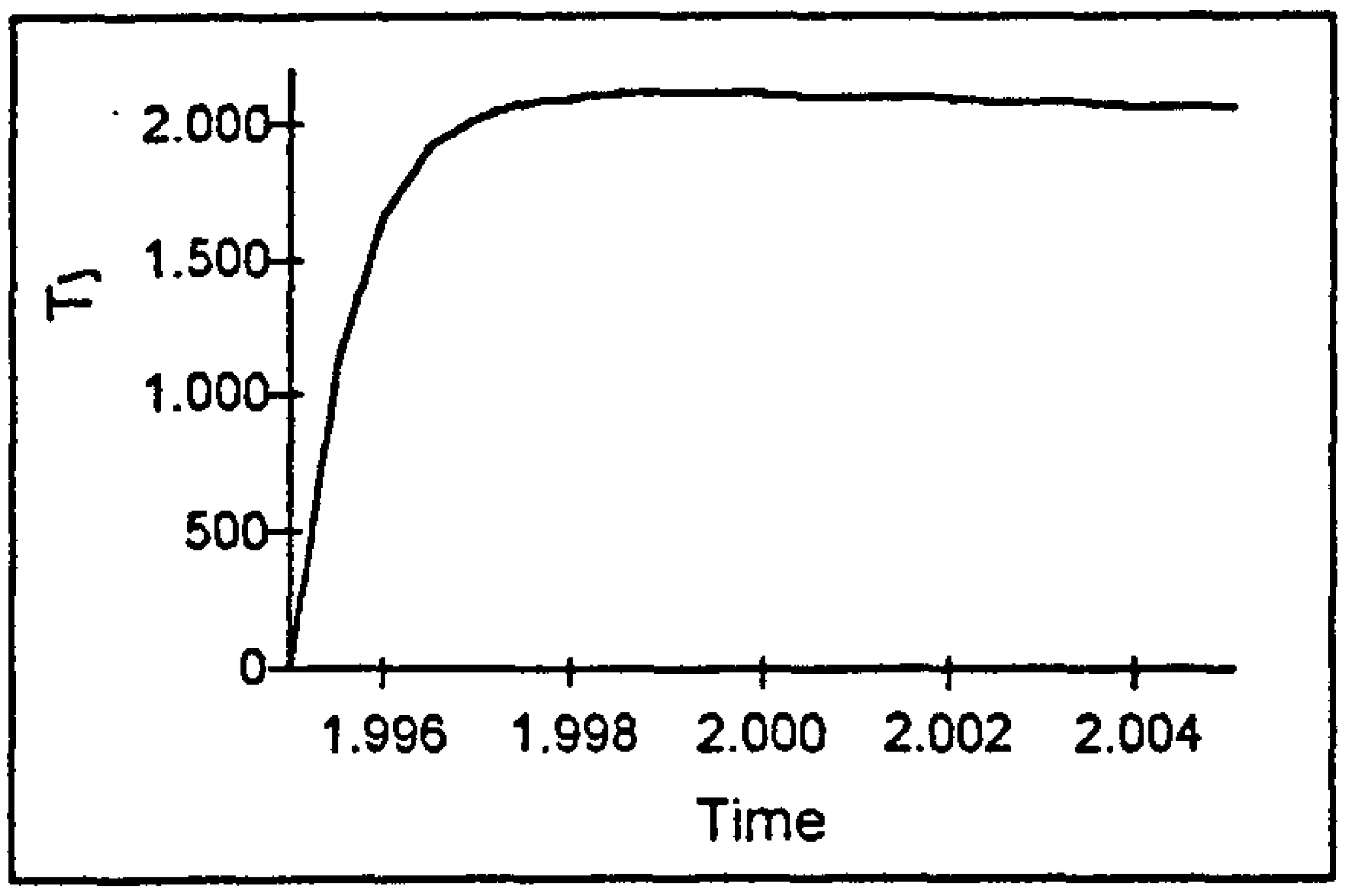
2.004
Time


T)
2.000
1.500
1.000
500
0
1.996
1.998
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2.002
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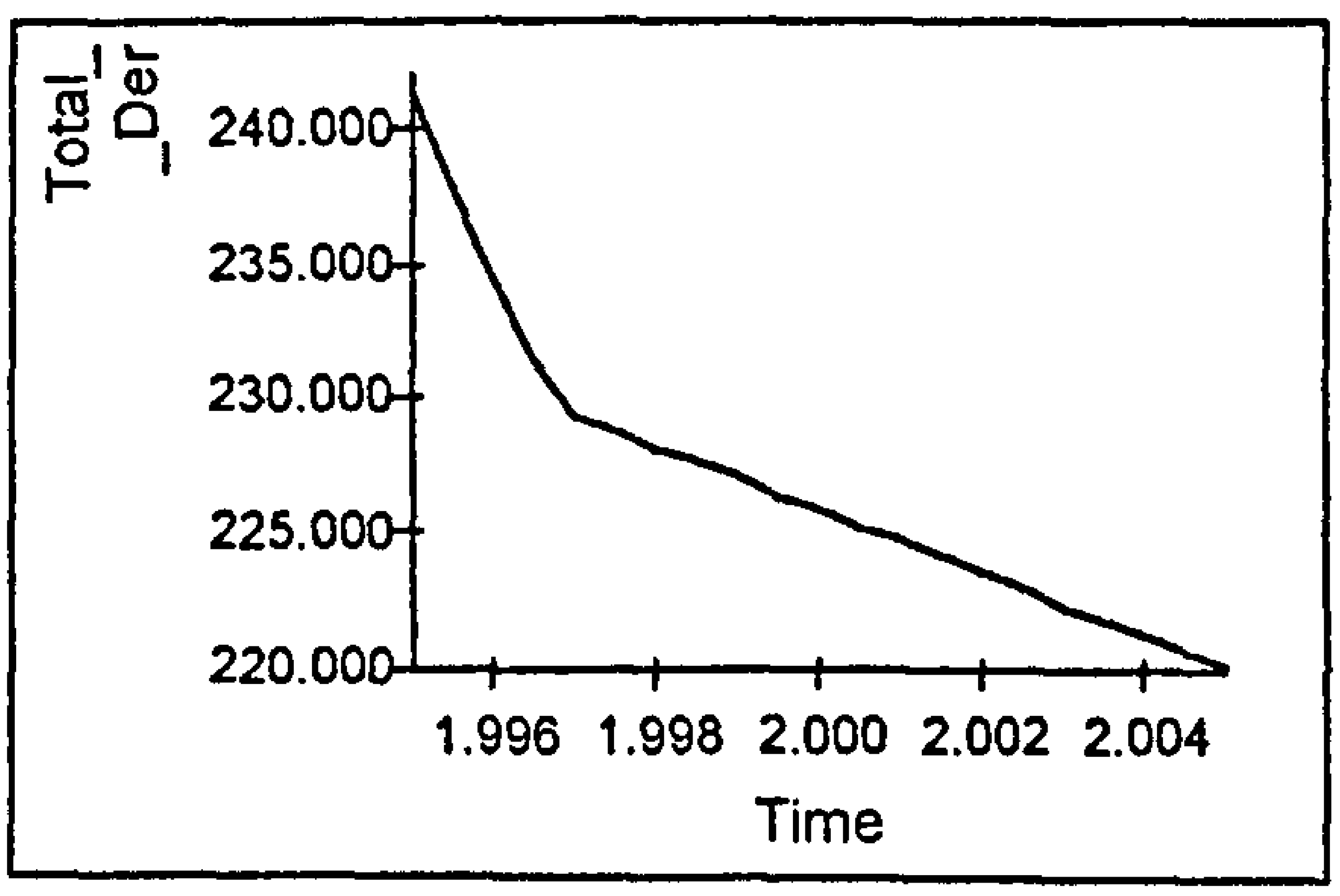
Time


Total_
_Der
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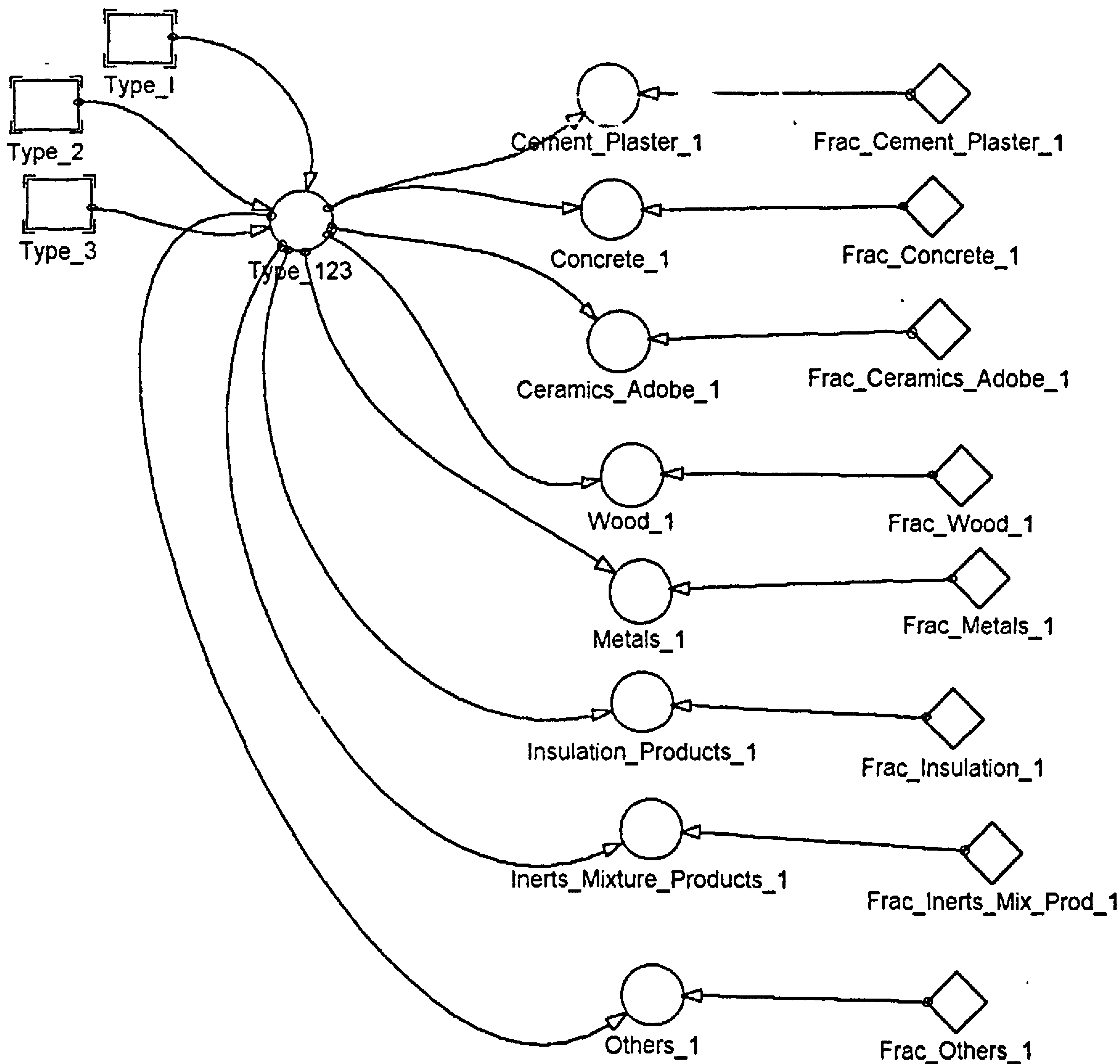
235.000
230.000
225.000
220.000
1.996
1.998
2.000
2.002
2.004
Time


Type_I
Type_2
Type_3
Type_123
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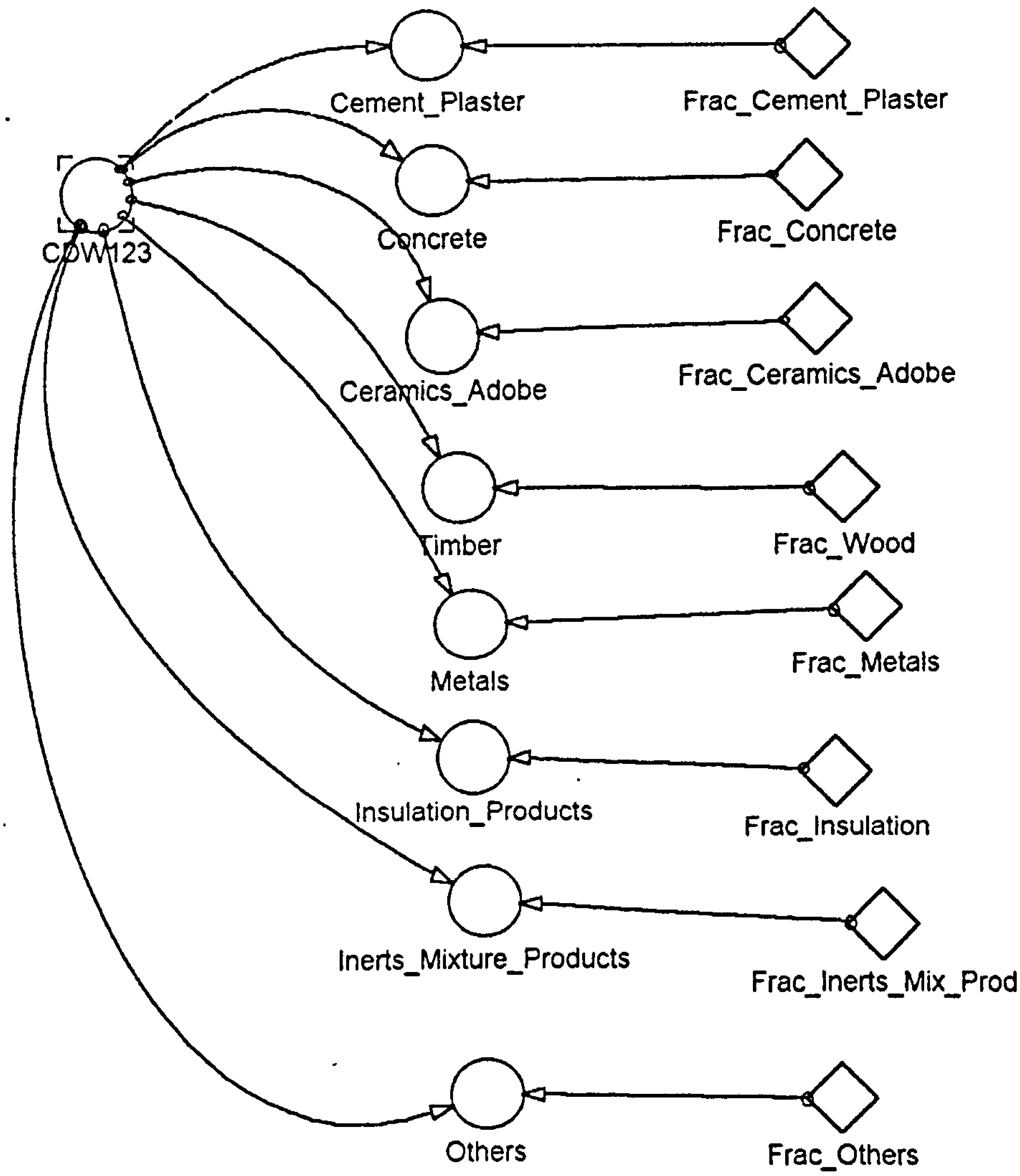
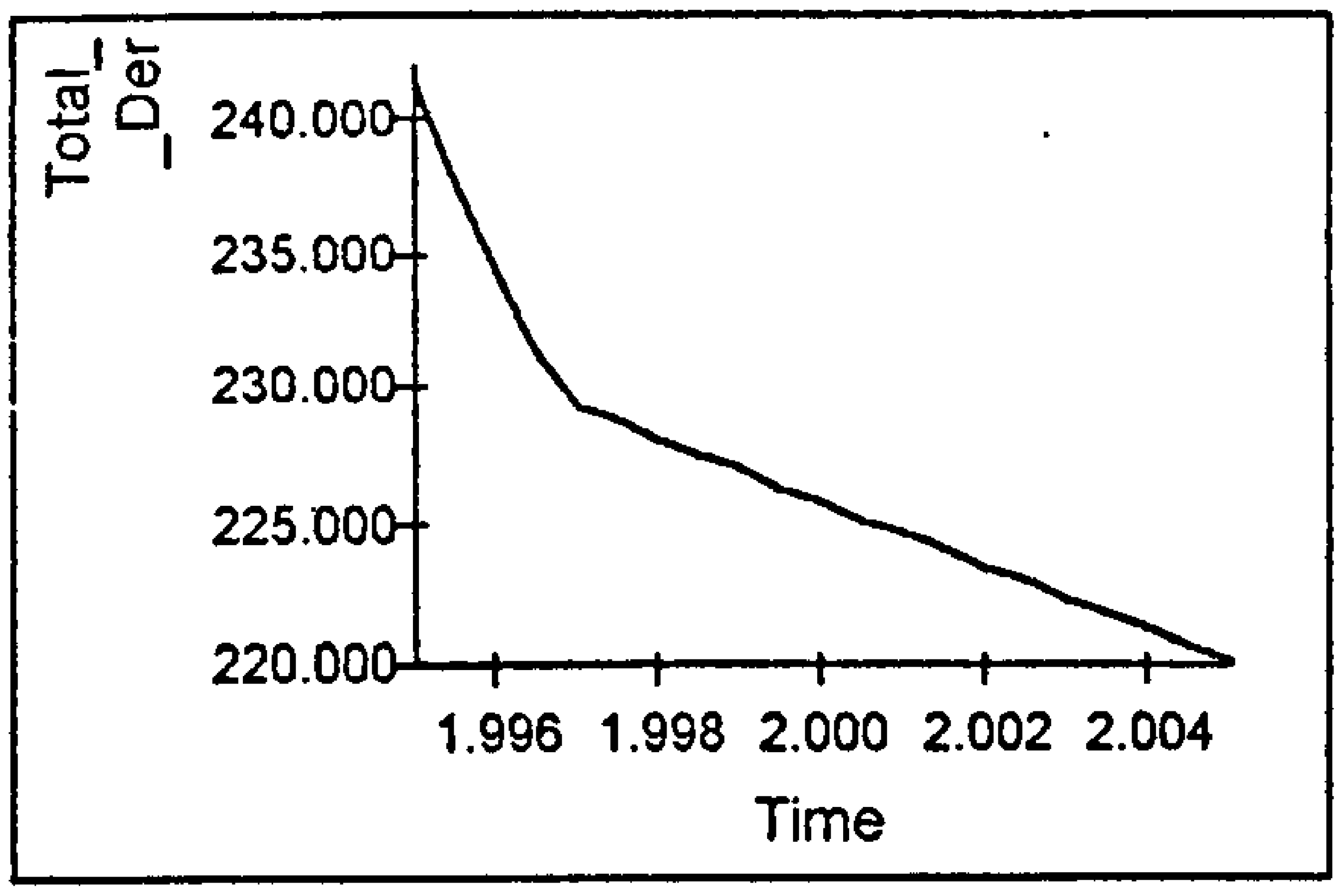
Frac_Cement_Plaster_1
Concrete_1
Frac_Concrete_1
Ceramics_Adobe_1
Frac_Ceramics_Adobe_1
Wood_1
Frac_Wood_1
Metals_1
Frac_Metals_1
Insulation_Products_1
Frac_Insulation_1
Inerts_Mixture_Products_1
Frac_Inerts_Mix_Prod_1
Others_1
Frac_Others_1

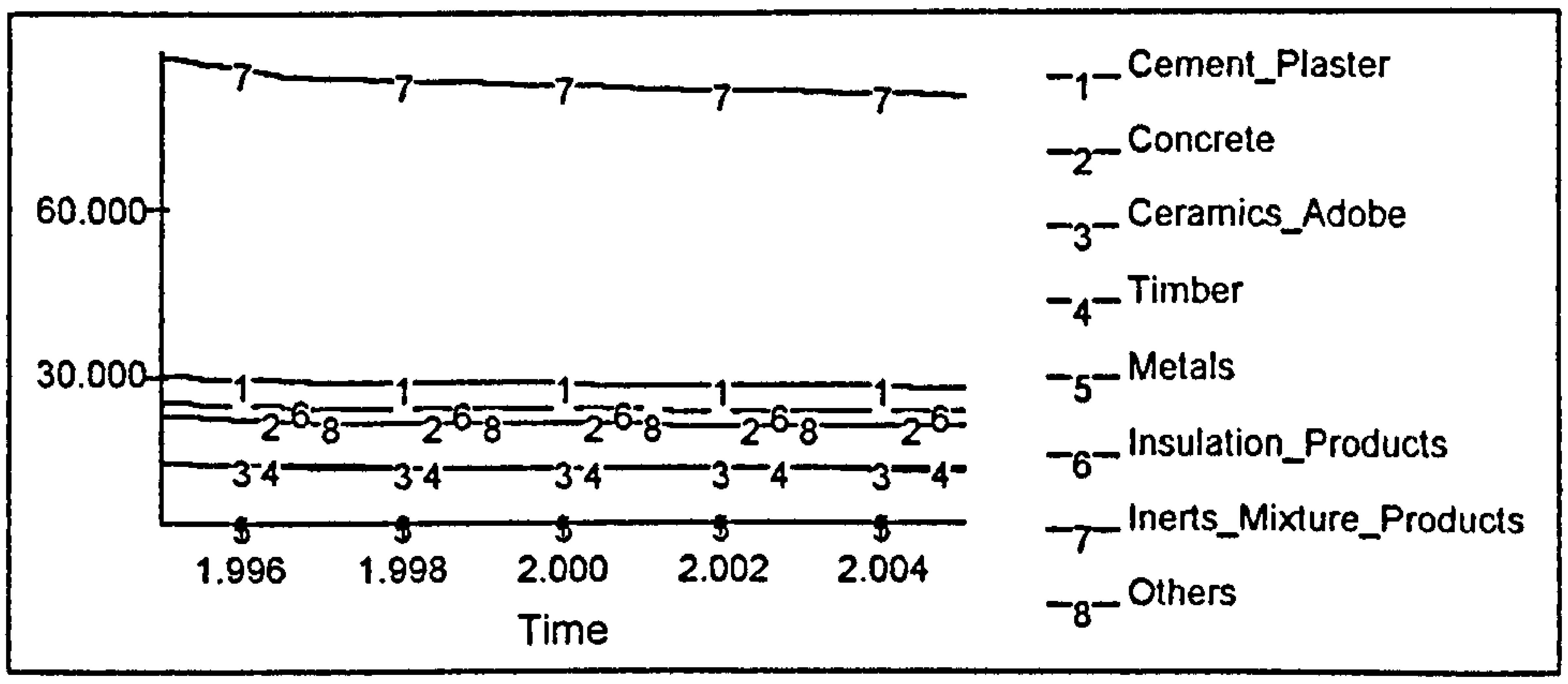


Cement_Plaster
Frac_Cement_Plaster
Concrete
Frac_Concrete
CDW123
Ceramics_Adobe
Frac_Ceramics_Adobe
Timber
Frac_Wood
Metals
Frac_Metals
Insulation_Products
Frac_Insulation
Inerts_Mixture_Products
Frac_Inerts_Mix_Prod
Others
Frac_Others

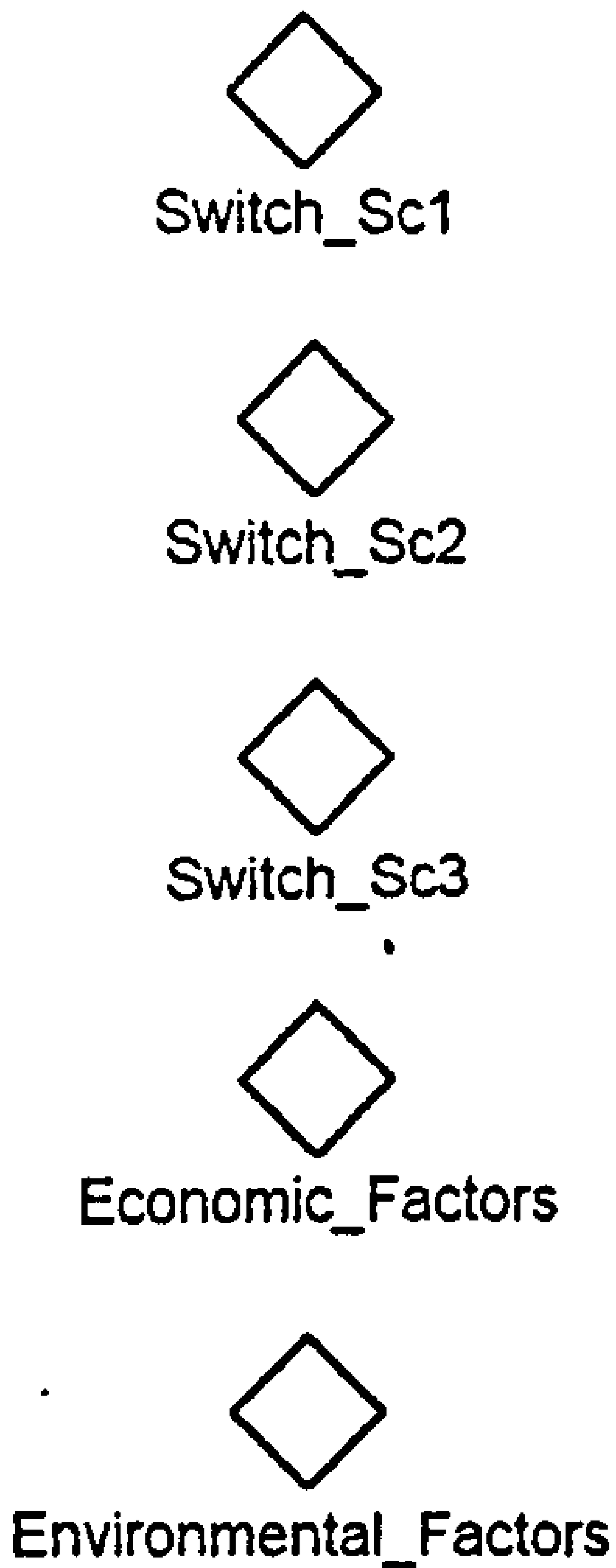
Time	ement_Plast	Concrete	eramics_Adol	Timber	Metals	ulation_Produ	_Mixture_Prc	Others
1.995,0	16.766,25	12.681,66	7.909,83	8.000,60	1.919,11	14.069,13	48.366,68	12.681,66
1.995,5	16.526,55	12.500,36	7.796,75	7.886,22	1.891,67	13.867,98	47.675,19	12.500,36
1.996,0	16.291,91	12.322,88	7.686,05	7.774,25	1.864,81	13.671,09	46.998,32	12.322,88
1.996,5	16.062,31	12.149,22	7.577,74	7.664,69	1.838,53	13.478,43	46.335,99	12.149,22
1.997,0	15.927,76	12.047,45	7.514,26	7.600,49	1.823,13	13.365,52	45.947,83	12.047,45
1.997,5	15.887,54	12.017,03	7.495,28	7.581,29	1.818,53	13.331,77	45.831,80	12.017,03
1.998,0	15.847,32	11.986,60	7.476,31	7.562,10	1.813,92	13.298,02	45.715,78	11.986,60
1.998,5	15.807,10	11.956,18	7.457,33	7.542,91	1.809,32	13.264,27	45.599,75	11.956,18
1.999,0	15.766,88	11.925,76	7.438,36	7.523,71	1.804,72	13.230,52	45.483,72	11.925,76
1.999,5	15.726,65	11.895,33	7.419,38	7.504,52	1.800,11	13.196,77	45.367,69	11.895,33
2.000,0	15.686,43	11.864,91	7.400,40	7.485,33	1.795,51	13.163,02	45.251,66	11.864,91
2.000,5	15.646,21	11.834,49	7.381,43	7.466,13	1.790,90	13.129,26	45.135,63	11.834,49
2.001,0	15.605,99	11.804,07	7.362,45	7.446,94	1.786,30	13.095,51	45.019,60	11.804,07
2.001,5	15.565,77	11.773,64	7.343,48	7.427,75	1.781,70	13.061,76	44.903,57	11.773,64
2.002,0	15.525,55	11.743,22	7.324,50	7.408,55	1.777,09	13.028,01	44.787,54	11.743,22
2.002,5	15.485,32	11.712,80	7.305,53	7.389,36	1.772,49	12.994,26	44.671,51	11.712,80
2.003,0	15.445,10	11.682,37	7.286,55	7.370,17	1.767,88	12.960,51	44.555,48	11.682,37
2.003,5	15.404,88	11.651,95	7.267,58	7.350,98	1.763,28	12.926,76	44.439,45	11.651,95
2.004,0	15.364,66	11.621,53	7.248,60	7.331,78	1.758,68	12.893,00	44.323,42	11.621,53
2.004,5	15.324,44	11.591,11	7.229,63	7.312,59	1.754,07	12.859,25	44.207,39	11.591,11
2.005,0	15.284,22	11.560,68	7.210,65	7.293,40	1.749,47	12.825,50	44.091,36	11.560,68

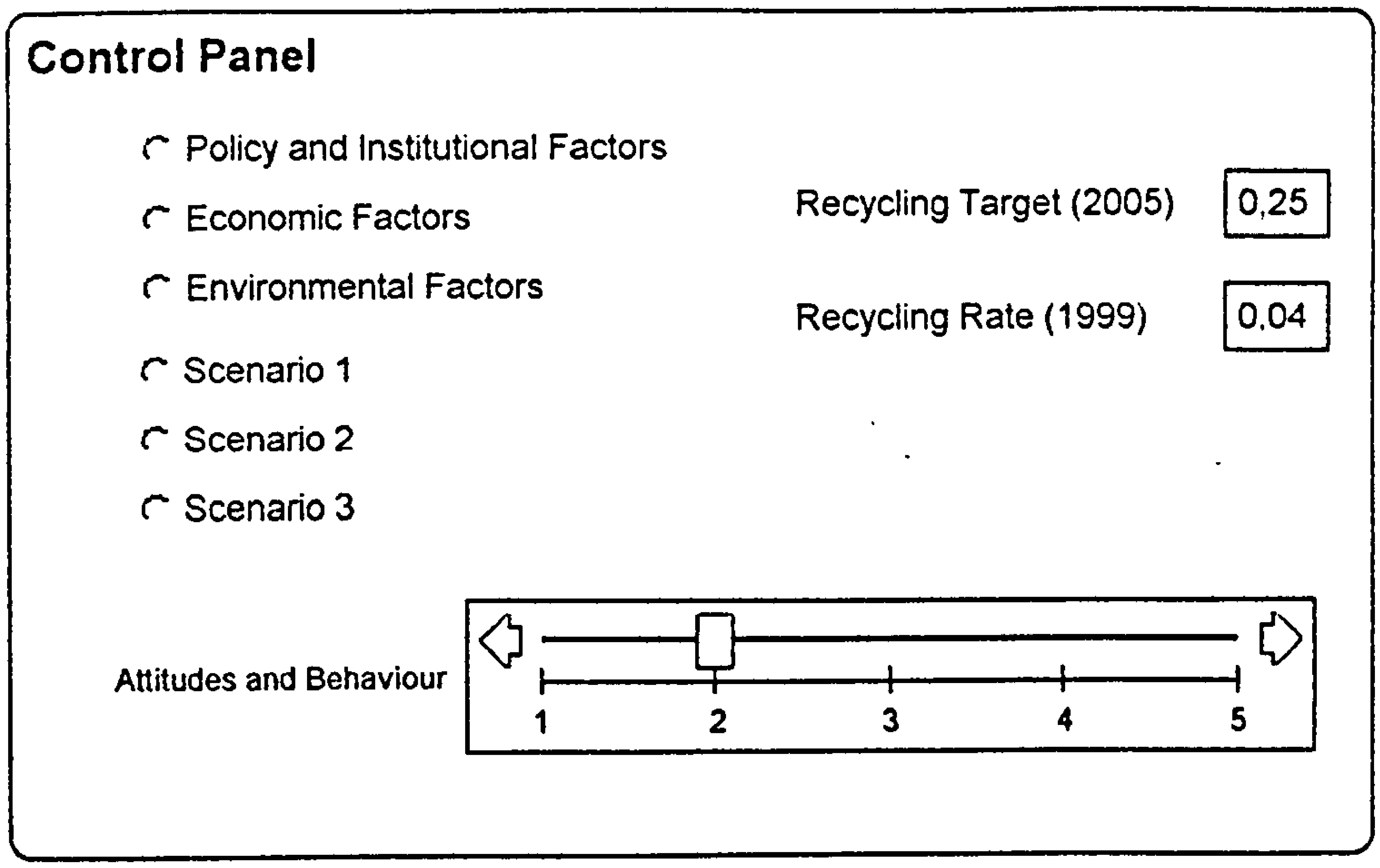


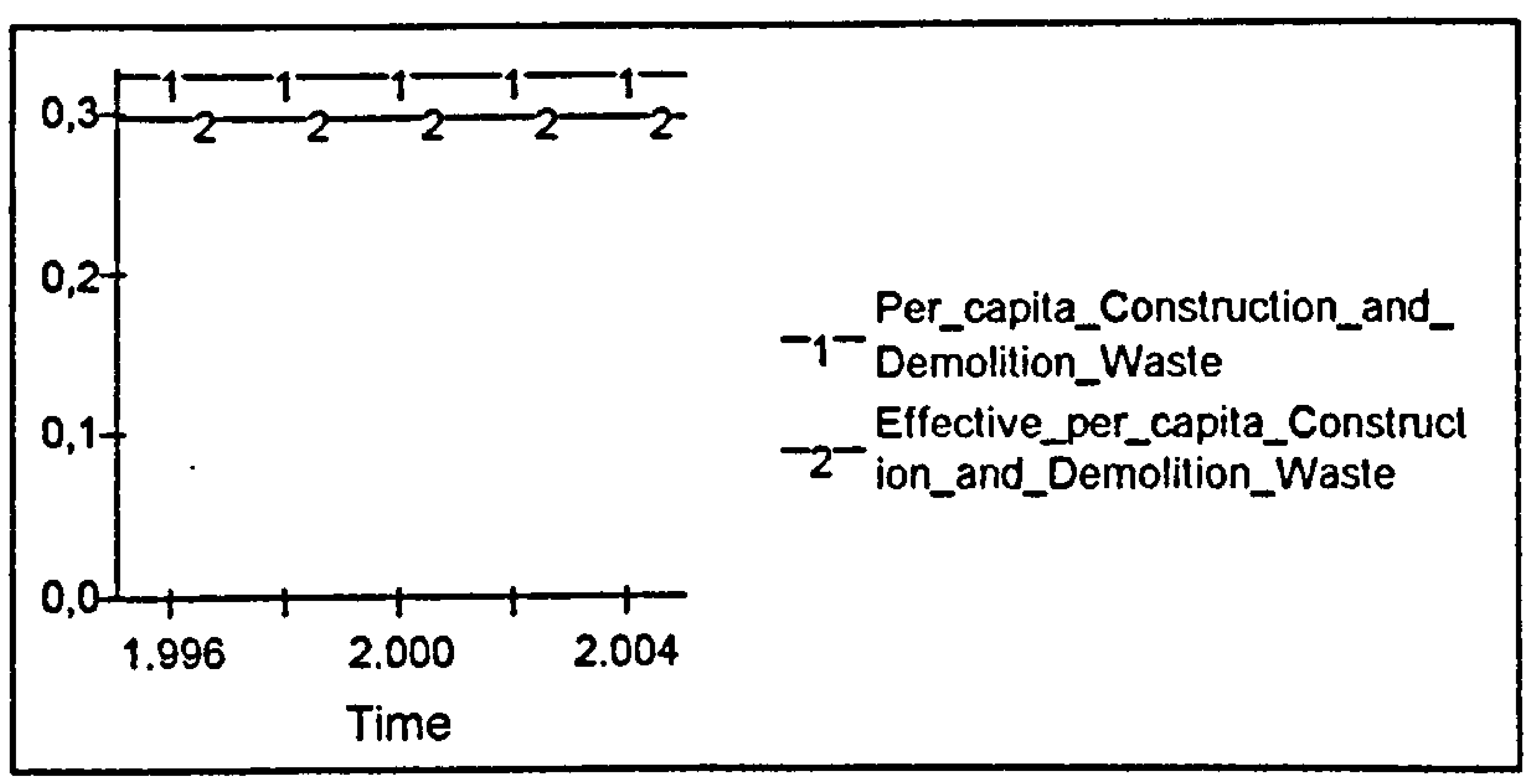
Total_
_Der
240.000
235.000
230.000
225.000
220.000
1.996 1.998 2.000 2.002 2.004
Time

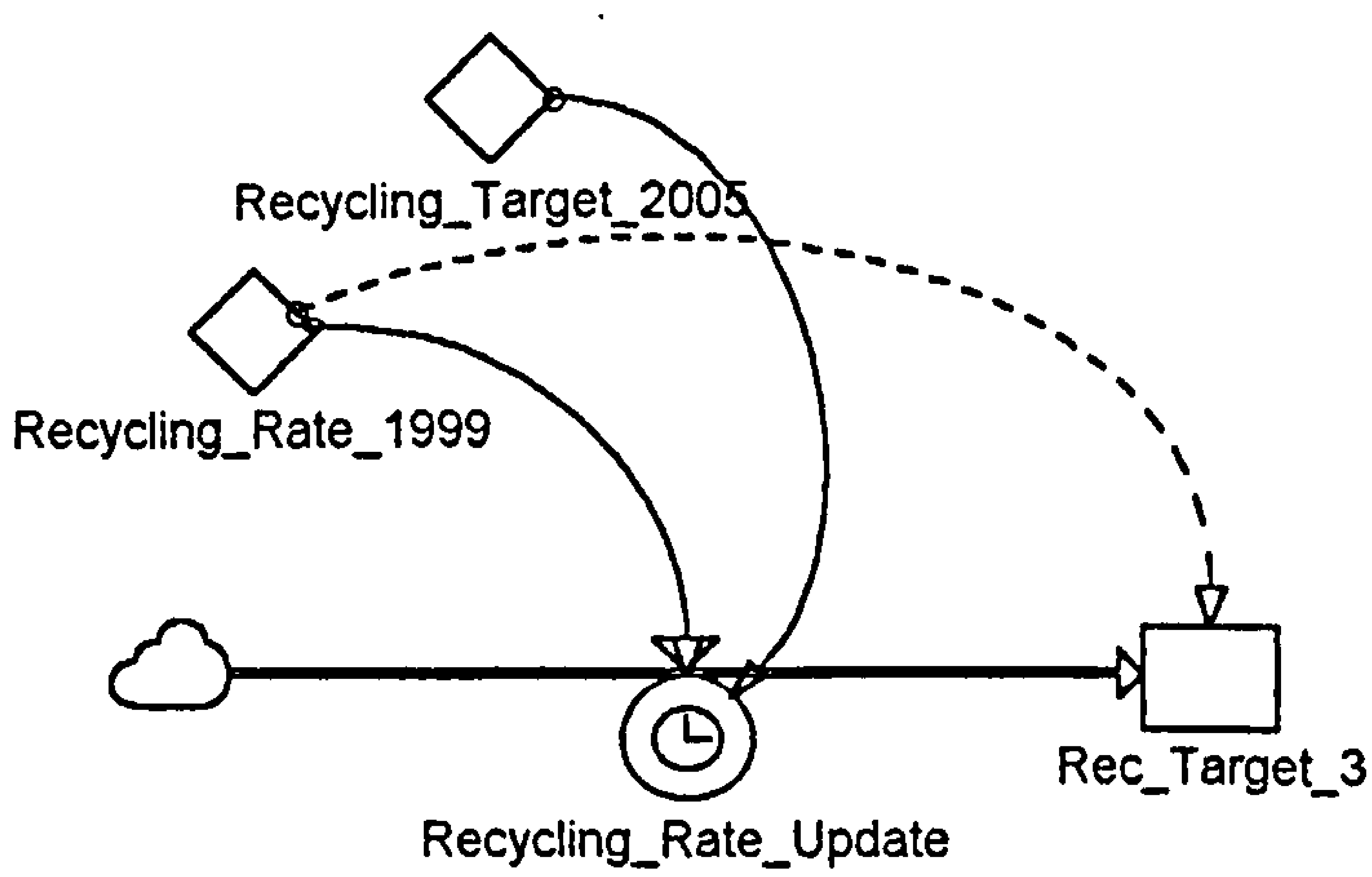


60.000
30.000
1.996 1.998 2.000 2.002 2.004
Time
1 Cement_Plaster
2 Concrete
3 Ceramics_Adobe
4 Timber
5 Metals
6 Insulation_Products
7 Inerts_Mixture_Products
8 Others


Switch_Sc1
Switch_Sc2
Switch_Sc3
Economic_Factors
Environmental_Factors


Control Panel
Policy and Institutional Factors
Economic Factors
Environmental Factors
Scenario 1
Scenario 2
Scenario 3
Recycling Target (2005)
0,25
Recycling Rate (1999)
0,04
Attitudes and Behaviour
1
2
3
4
5


0,3
0,2
0,1
0,0
1.996
2.000
2.004
Time
1 Per_capita_Construction_and_Demolition_Waste
2 Effective_per_capita_Construction_and_Demolition_Waste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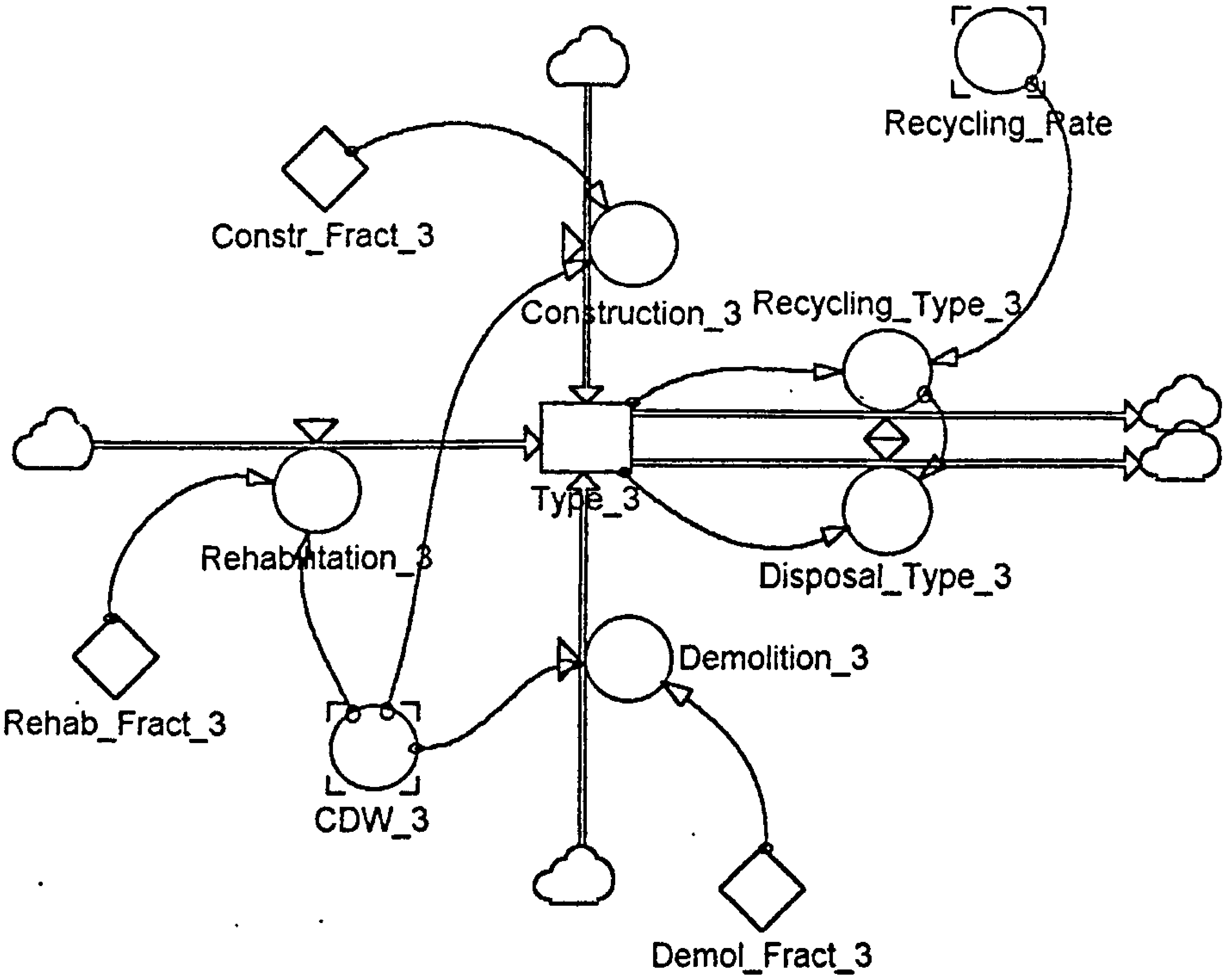
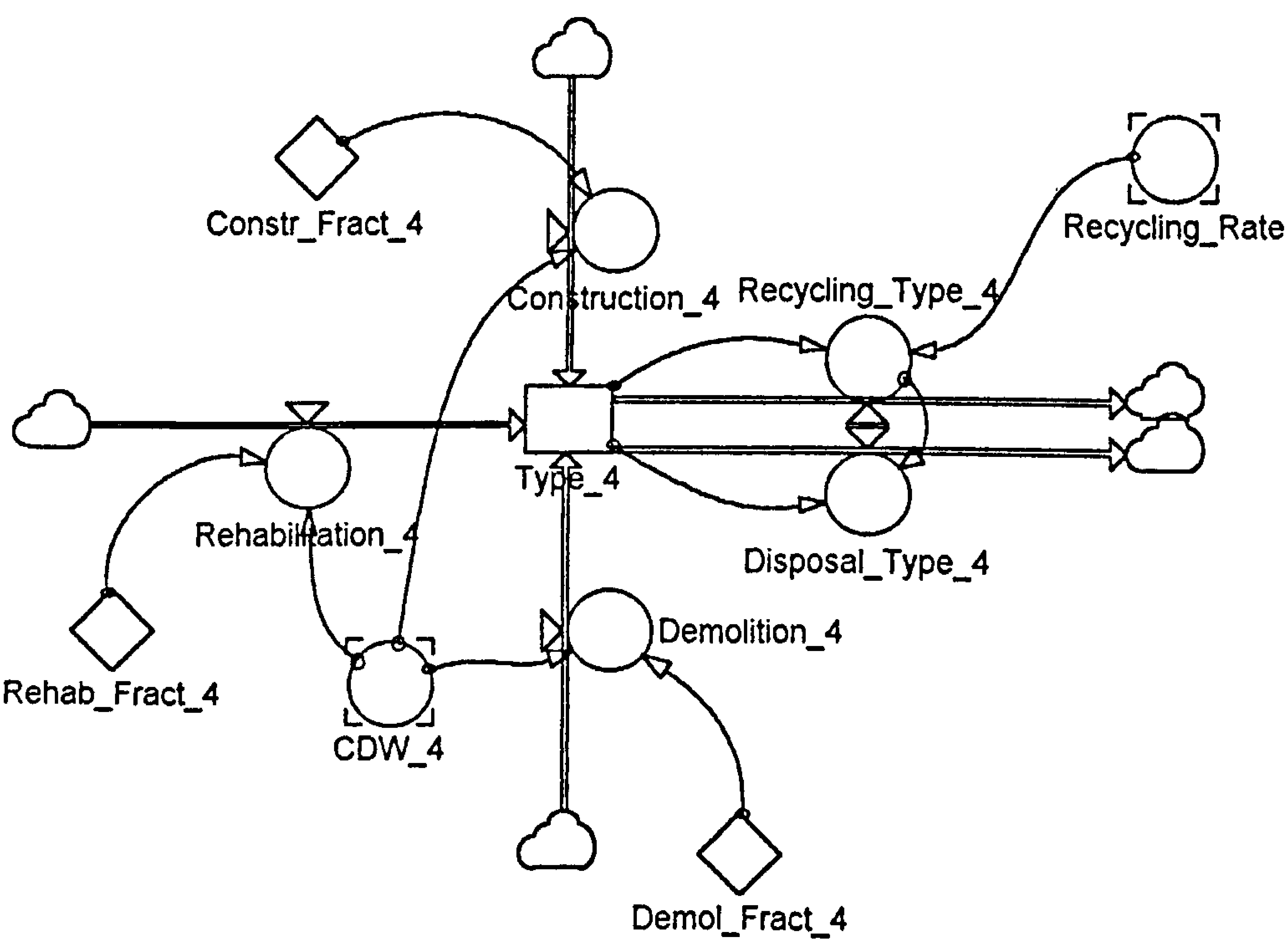
Recycling_Rate_1999
Rec_Target_3
Recycling_Rate_Update


Recycling_Rate
Constr_Fract_3
Construction_3
Recycling_Type_3
Type_3
Rehabilitation_3
Disposal_Type_3
Demolition_3
Rehab_Fract_3
CDW_3
Demol_Fract_3


Constr_Fract_4
Recycling_Rate
Construction_4
Recycling_Type_4
Type_4
Rehabilitation_4
Disposal_Type_4
Demolition_4
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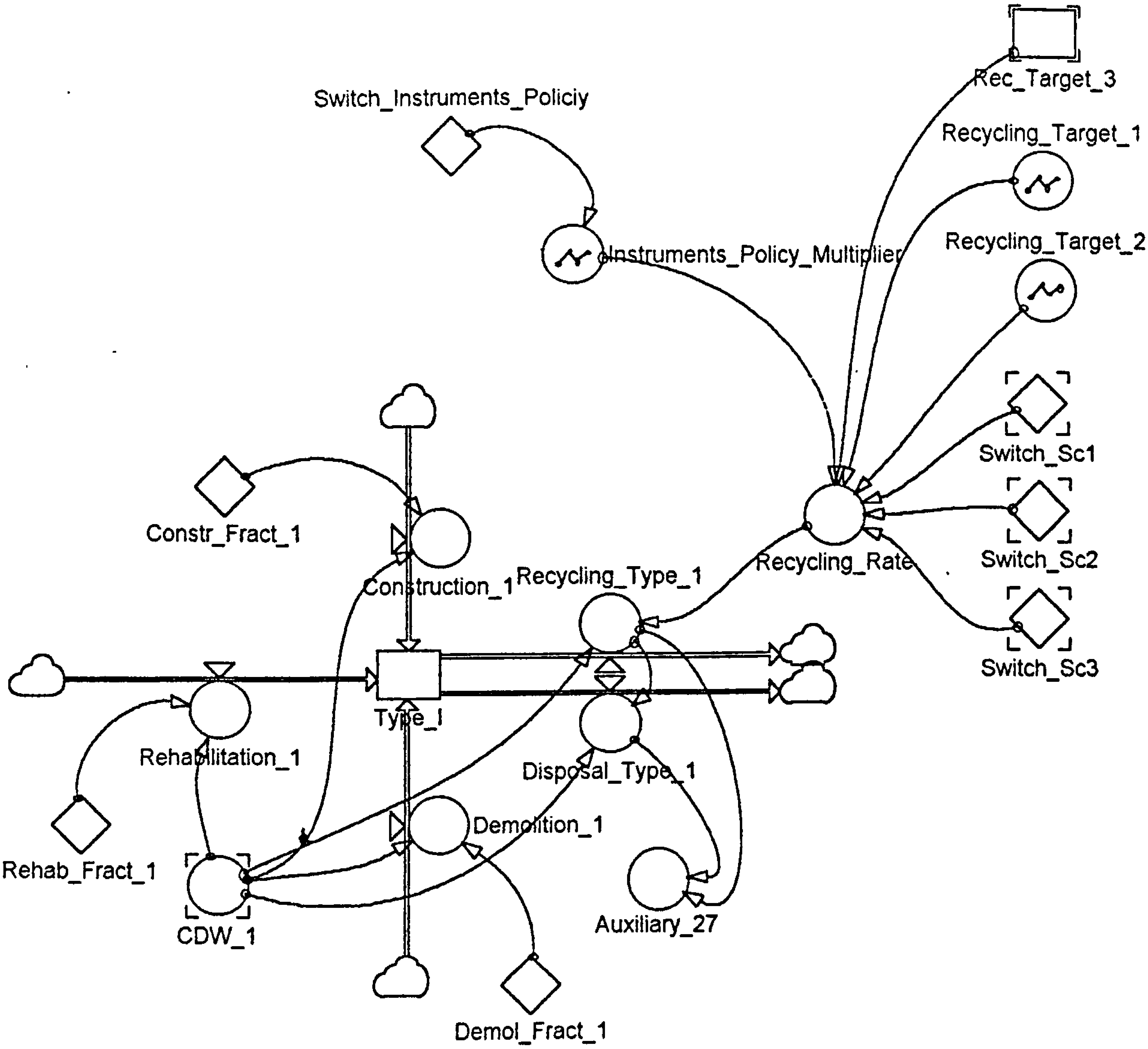
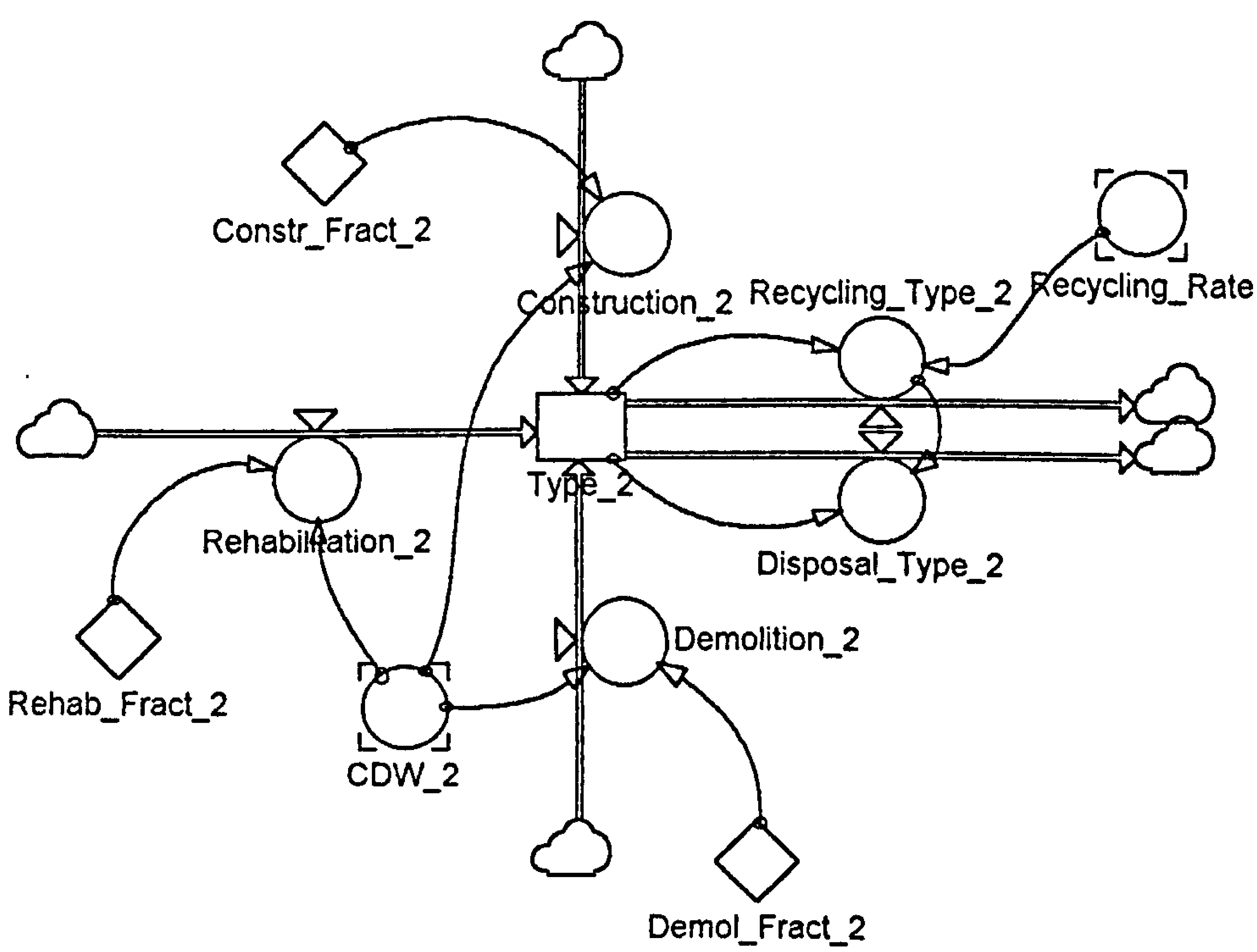
CDW_4
Demol_Fract_4


Rec_Target_3
Switch_Instruments_Policiy
Recycling_Target_1
Instruments_Policy_Multiplier
Recycling_Target_2
Switch_Sc1
Constr_Fract_1
Recycling_Rate
Switch_Sc2
Construction_1
Recycling_Type_1
Switch_Sc3
Type_I
Rehabilitation_1
Disposal_Type_1
Demolition_1
Rehab_Fract_1
Auxiliary_27
CDW_1
Demol_Fract_1


Constr_Fract_2
Construction_2
Recycling_Type_2
Recycling_Rate
Type_2
Rehabilitation_2
Disposal_Type_2
Demolition_2
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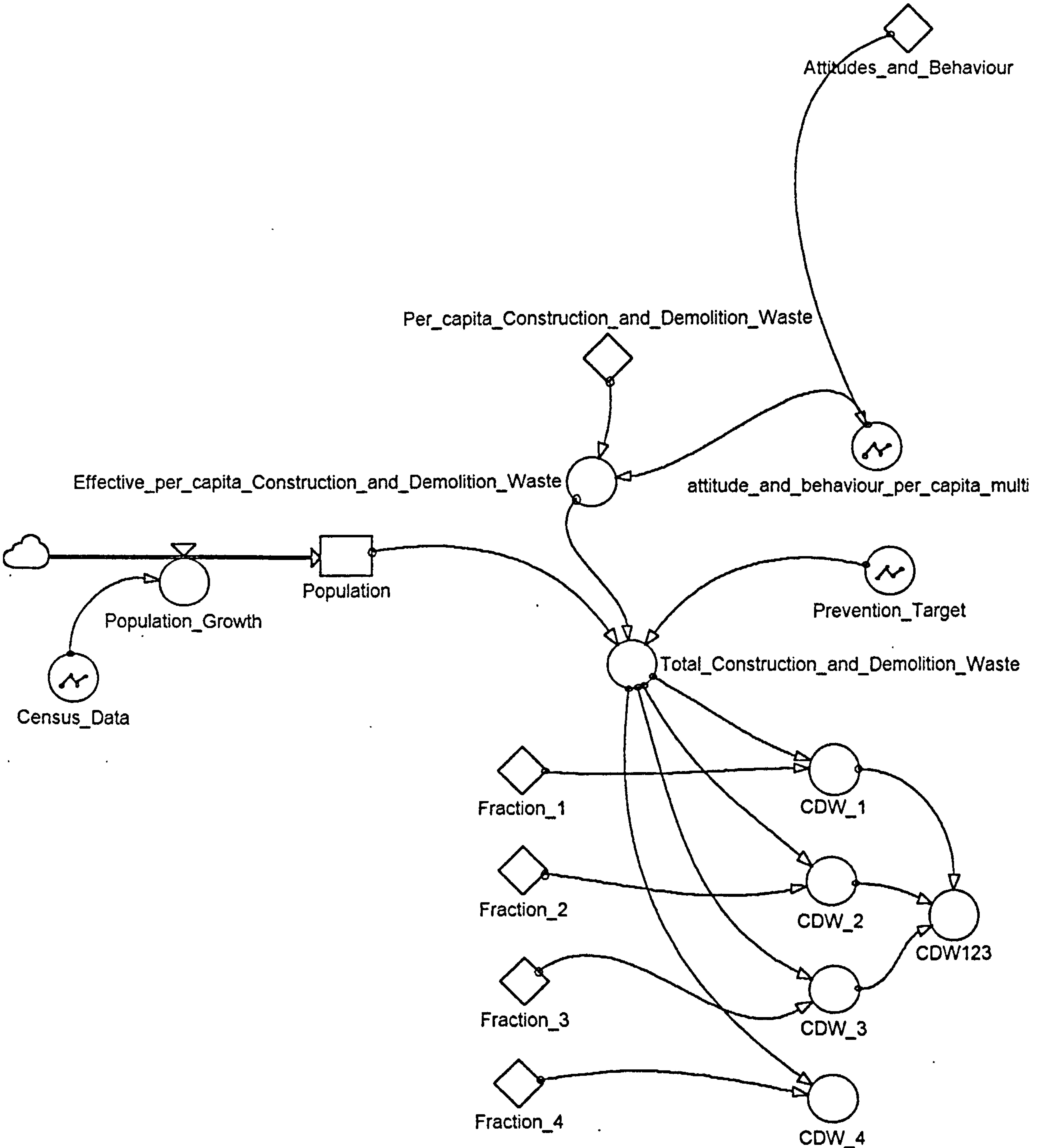
CDW_2
Demol_Fract_2


Attitudes_and_Behaviour
Per_capita_Construction_and_Demolition_Waste
Effective_per_capita_Construction_and_Demolition_Waste
attitude_and_behaviour_per_capita_multi
Population
Population_Growth
Census_Data
Prevention_Target
Total_Construction_and_Demolition_Waste
Fraction_1
CDW_1
Fraction_2
CDW_2
CDW123
Fraction_3
CDW_3
Fraction_4
CDW_4

APPENDIX G:

MODEL DYNAMIC (CD Files)

THESIS CONTAINS

VIDEO CD DVD TAPE CASSETTE

APPENDIX H:

FIFTY SIX RECOMMENDATIONS FROM MORGAN AND ARGUS (1995) REPORT

APPENDIX H:

FIFTY SIX RECOMMENDATIONS FROM MORGAN AND ARGUS (1995) REPORT

3 WASTE MANAGEMENT

3.1 Common definitions in construction and demolition waste management

3.1.1 The Group considers that common and harmonized definitions of construction and demolition wastes are an essential requirement in order that market transparency can be achieved, and the setting and monitoring of targets undertaken.

3.1.2 The Commission has published its Decision establishing a list of wastes pursuant to Article 1 (a) of Council Directive 75/442/EEC on waste, as amended by Council Directive 91/1 56/EEC. Details of this list, known as the 'European Waste Catalogue', are given in Commission Decision 94/3/EC published in the Official Journal of 7th January 1 994.

3.1.3 The Decision notes that the list is a harmonized, non-exhaustive list of wastes subject to periodic review and revision, and that it is to be a reference nomenclature providing a common terminology relating to waste management activities.

3.1.4 The Project Group recognizes the difficulties the Commission has had in producing a list suitable for application across the wide range of waste management activities, but it notes that there will be difficulties in using a list prepared for administrative purposes in operational situations.

3.1.5 In this regard the Group considers that the European Waste Catalogue provides a useful framework for waste management planning purposes but that it requires further refinement and elaboration if it is to be used in operational situations.

3.1.6 **Recommendation No.1** [S5.61]: - The *Commission should seek to ensure that waste management planning and operational considerations are taken into account in future adaptations of the European Waste Catalogue.*

.D Notwithstanding this difficulty the Project Group is of the opinion that the European Waste Catalogue should be the basis on which future construction and demolition waste management planning is undertaken.

RECOMMENDATIONS OF THE PROJECT GROUP

3.1.8 Representatives of the authorities responsible for waste management planning also consider that it is necessary to identify those components of Construction and Demolition Wastes which are hazardous in order to facilitate the provision of appropriate treatment facilities.

3.1.9 **Recommendation No.2** *[S5.6]: - Member States should be encouraged to adopt the following classifications (taken from the European Waste Catalogue) as the framework within whic!1 future construction and demolition waste management planning will undertaken and waste arising data collected and reported:*

(i) concrete, bricks, tiles, ceramics, and gypsum based materials (EWC code 17 0100);

(ii) wood (EWC code 17 02 01);

(iii) glass (EWC code 17 02 02);

(iv) plastic (EWC code 17 02 03);

(v) asphalt, tar and tarred products (EWC code 17 03 00);

(vi) metals (including their alloys) (EWC code 17 04 00);

(vii) soil and dredging spoil (EWC code 17 05 00);

(viii) insulation materials (EWC code 17 06 00);

(ix) mixed construction and demolition waste (EWC code 17 07 00). Hazardous components of Construction and Demolition Wastes should also be identified.

3.1.10 **Recommendation No.3** *[S5.6]: - The classifications proposed in paragraph 3.1.9 should be modified (on a Europe-wide basis) in line with subsequent adaptations of the European Waste Catalogue.*

3.1.11 The Group acknowledges that some Member States have already developed sophisticated waste classification systems.

3.1.12 **Recommendation No.4** - *The requirements proposed in paragraph 3.1.9* ***should not*** *prevent Member States from* ***maintaining or improving existing waste classification*** *systems provided that data collection and monitoring, and the provision of information to the Commission, is undertaken on the basis of classifications which are compatible with, and Can be directly related to, those given in paragraph 3.1.9. The Commission should be informed of such classification systems.*

3.1.13 There has been some discussion within the Project Group as to the nature of recovery and disposal operations, and to the detail in which data on such operations should be collected.

7.1.12 For the purpose of the development of the Strategy and Recommendations of the Project Group the following broad definitions of waste recovery and disposal operations were adopted by the Group:

(i) Recovery has been taken to include:

(a) re-use;

(b) recycling; and,

(c) incineration with energy recovery.

(ii) Disposal has been taken to include:

(a) incineration without energy recovery;

(b) landfill.

3.1.15 For full details of the legal definitions of waste, and recovery and disposal operations, reference should be made to Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC.

3.1.16 With regard to the collection of data relating to recovery and disposal operations required to facilitate waste management planning, and the associated reporting, the

Project Group proposes the adoption of four simple classifications.

7.1.12 **Recommendation No.5** [S5.7]: - *Data relating to recovery and disposal operations should be collected on the basis of the following broad categories:*

(i) for recovery of materials;

(ii) for recovery of energy;

(iii) for disposal by incineration without energy recovery;
(iv) for disposal to landfill.

3.2 Promoting recovery from construction and demolition waste

3.2.1 The Group considers that the use of products and materials containing or derived from secondary ;products and materials is constrained by the identification of such materials as waste under the definition of waste given in Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC. The Group considers that products and materials destined for re-use and recycling should not be classified as waste.

3.2.2 **Recommendation No.6** *[S5.6]: - The Commission should review the definition of waste in Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC, with the objective of developing a proposal whereby products and materials destined for re-use and recycling are not defined as waste.*

3.2.3 The Group notes that many processes for recovery of materials and energy from waste have already been developed and are successfully in operation. The Group also notes that there is some utilization of secondary materials in construction works in some Member States. In both cases, however, the extent to which these have been adopted across the Union is limited.

3.2.4 The Group considers that a Europe-wide approach to the promotion of recovery from waste is required and that this is an appropriate role for the Commission and the European professional and trade associations and federations.

7.1.12 **Recommendation No.7** *[S5.7, S6.2, S6.3, S6.4, S8.2]: - The Commission should fund*

(i) the collection, review and dissemination of data relating to recovery from construction and demolition waste, and associated research projects;

(ii) the promotion of the wider adoption of recovery technology; and,

(iii) the promotion of the wider use of secondary materials in the construction and other sectors.

3.2.6 **Recommendation No.8** *[S5.7, S6.2]:- The European Commission and European professional and trade associations and federations should organize seminars and conferences at which existing knowledge can be disseminated, and experiences exchanged between participants in the construction and demolition sector. Particular attention should be given to informing those responsible for waste management planning of the technologies and processes available for recovery, and the economic and environmental issues associated with them.*

7.1.13 **Recommendation No.9** *[S6.2, S6.3, S6.4, S8.2]: - The Commission should fund research or pilot projects with the objectives of:*

(i) identifying the constraints to the wider adoption of recovery *from construction and demolition waste;*

(ii) adapting existing processes and methodologies to the different approaches adopted by building and civil engineering industries in the Union;

(iii)developing new recovery and waste management techniques; and,

(iv) developing new uses for secondary materials in construction and other sectors.

3.2.8 The Project Group believes that recovery from waste can be constrained by the inability of promoters, operators, and contractors to obtain the necessary consents, and establish waste treatment and material recovery facilities, within a time scale commensurate with the associated construction and demolition activities.

7.1.12 **Recommendation No.10** *[S8.3]:- Legislation regulating the environmental impacts of waste treatment and material recovery facilities should be developed and implemented at national level. Europe-wide harmonization of the approvals process for* treatment *facilities should be encouraged. The proposed approvals framework should allow:*

(i) specified limits on approval processing periods;

(ii) a presumption in favor of granting an approval where this is consistent with adopted land use and waste management planning requirements.

3.2.10 With regard to the recommendation given in paragraph 3.2.9 the Project Group notes that the proposal for a Council Directive on Integrated Pollution Prevention and Control, currently under discussion, may impose further controls on some waste recovery and disposal operations. This recommendation will therefore have to be reviewed in the light of this legislation.

7.1.13 The Project Group notes that, with regard to waste management and the promotion of recovery, Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC, requires Member States to:

(i) establish an integrated network of disposal installations (Article 5 refers);and,
(ii) draw up waste management plans (Article 7 refers).

7.1.14 The Project Group is of the opinion that recovery will be promoted if the use of incineration without energy recovery and landfill for the disposal of potentially recoverable materials is discouraged. Notwithstanding this the Group acknowledges that:

(i) there will be circumstances where disposal will remain the most appropriate solution; and,

(ii) recovery may only be possible up to a certain level.

3.2.13 The Project Group has also concluded that, as a general rule, mechanisms to control disposal practices are more appropriately administered through the waste management planning process. This approach allows differing national, regional and local circumstances to be taken into account.

3.2.14 The Group acknowledges that there is the potential for causing distortions in the market through the imposition of local controls, taxes and levies on disposal. In this respect Member States and 'competent authorities' should ensure that such distortions do not occur.

7.1.12 **Recommendation No.11** *[S7.3]: - Member States and their 'competent authorities' for waste management planning should consider the following options when assessing the measures necessary to improve the management of construction and demolition wastes. The measures adopted should avoid distorting the market and lead to demonstrable environmental benefit. The options available include, for example:*

(i) selective restrictions or bans on the disposal of recoverable materials;

(ii) total bans on the disposal of certain materials;

(iii) the mono-landfill of certain materials for possible future recovery.

(iv) tightening environmental and planning controls on disposal;

(v) the imposition of local, regional or national taxes or levies on the disposal of recoverable materials.

3.2.16 The Project Group considers it highly desirable and appropriate that some of the monies raised from taxation or levies on the disposal of construction and demolition wastes should be used for funding the promotion of recovery from such wastes.

3.2.17 **Recommendation No.12** *[S7.3]: - Funds collected as a result of taxation or the imposition of levies on the disposal of construction and demolition wastes should be used to promote recovery from such wastes. This could include, for example, the* *funding of.*

(i) *data collection and research;*

(ii) *education and training in waste prevention and material recovery techniques;*

(iii) *pilot projects on collection, separation and recovery;*

(iv) *the provision of separation and recovery installations.*

3.3 **Data on recovery from waste and disposal**

3.3.1 The Group affirms the need for the planning of construction and demolition waste management but notes that in many cases the existing data is inadequate.

3.3.2 The Group considers that direct recording of waste prevention is impractical. Notwithstanding this the Group considers that the data necessary to facilitate waste management planning can be obtained from data collection undertaken at the transportation, recovery and disposal stages of waste management.

3.3.3 The opportunities for data collection from the transportation phase of construction and demolition waste management are addressed in more detail in section 3.7 below.

3.3.4 With regard to recovery and disposal operations Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC, already requires establishments undertaking specified disposal and recovery operations to obtain permits. However this Directive also includes exemptions and there is a lack of clarity on the data required under the specified permit systems.

7.1.12 **Recommendation No.13** *[S5.7]: - The Commission should review the terms of Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC, and make proposals for:*

(i) *ensuring that construction and demolition waste treatment and material recovery operations are brought within the terms of appropriate permit systems;*

(ii) *requiring construction and demolition waste treatment and material recovery and disposal establishments to collect and report data on:*

(a) *the types and quantities of wastes (paragraph 3.1.9 refers);*

(b) *the treatment and/or disposal methods (identifying the types and* *quantities of waste receiving each treatment - paragraph 3.1.17 refers);*

(c) *he products recovered (identifying types and quantities).*

3.4 Waste management planning

3.4.1 Waste management planning is already a requirement of Article 7 of Council Directive 75/442/EEC on waste, as amended by Council Directive 91/156/EEC. Paragraph 2.1.3 above notes that the Project Group is proposing that the majority of waste management measures recommended are implemented at the appropriate local or regional level.

3.4.2 Similarly paragraph 2.1.4 notes that this approach is consistent with the waste management planning procedures put in place by a number of Member States whereby the 'competent authorities' have generally been constituted at a regional or local level.

3.4.3 However, with regard to construction and demolition wastes in particular, the Group considers that further guidance on the issues to be addressed in these plans is required.

3.4.4 The Project Group is also concerned that, in undertaking their waste management planning, competent authorities should take account of the requirements of the local construction, demolition and waste management industries regarding planning for capital investment in recovery from waste, in particular the need for long term consistency in waste management requirements.

3.4.5 **Recommendation No.14** *[S9.3]: - The competent authorities of the Member States should consult with local construction, demolition and waste management industries, as part of the waste management planning process.*

3.4.6 **Recommendation No.15** *[S9.3]: - With regard to construction and demolition wastes, the competent authorities of the Member States should, wherever possible, address the following Issues in their waste management plans:*

(i) *predictions of waste arising by approximate location (ie. local administrative areas);*
(ii) *predictions of waste arising by European Waste Catalogue classification (paragraph 3.1.9 refers);*

(iii) *targets for recovery and disposal;*

(iv) *predicted demand for facilities for recovery from construction and demolition waste;*

(v) *the contribution of product and material 'return' and 'collect' systems (refer also to paragraph 5.4.6);*

(vi) *predicted long term disposal requirements;*

(vii) *the existing recovery facilities;*

(viii) *predicted requirements for interim storage to facilitate economic treatment of materials;*

(ix) *predicted need for long term storage sites (mono-landfill) to balance the supply and demand of secondary materials;*

(x) *existing disposal facilities;*

(xi) *environmental issues to be addressed in the siting of new recovery and disposal facilities;*

(xii) *identification of preferred locations/sites for new recovery facilities;*

(xiii) *identification of preferred locations/sites for new disposal facilities;*

(xiv) *advice on sources of funding, grants and loans, that may be available for waste management projects.*

3.4.7 **Recommendation No.16** *[S5.6, S5.7, S9.3]: - The competent authorities of the Member States should adopt the following in their waste management plans:*

(i) *the classifications of waste described in paragraph 3.1.9 above;*

(ii) *the broad categorization of the various recovery options as identified in paragraph 3.1. 17;*

(iii) *that the sections of the waste management plans dealing with construction and demolition wastes should cover a period of at /east 15 years;*

(iv) *that routine monitoring of the actions and achievements proposed in the plan should be undertaken; and,*

(v) *that routine updating of the waste management plans should be undertaken at intervals of not more than every 5 years.*

3. 5 Targets

3.5.1 Targets for improvements in recovery from waste and waste disposal are acknowledged as a necessary tool in the achievement of improvements in recovery and disposal.

3.5.2 The Group considers that targets should be meaningful and practicable and are not in favour of mandatory targets, or of obligations being imposed requiring industry to meet targets.

7.1.12 The Group recognizes that targets can be set at a number of levels, namely:

(i) local;

(ii) regional;

(iii) national; and,

(iv) European.

3.5.4 However the Group considers that the data presently available on construction and demolition wastes is neither consistent or complete. In the majority of Member States the data available does not permit the setting of meaningful targets.

3.5.5 The Group is of the opinion that detailed targets are most appropriately set at the operational level, ie. the local level, where the issues affecting recovery from, and disposal of, the wastes can be identified.

3.5.6 However the Group also recognizes that regional and national administrations, and the European Union, may also wish to set broader targets by way of encouragement to the general process of improvement.

3.5.7 The Group considers that targets should be consistent with adopted waste management plans, based on clearly defined environmental objectives, and at the level of detail appropriate to the level of administration setting the target.

7.1.12 **Recommendation No.17** *[S9.3]: - Targets should be set by the 'competent authorities', local, regional, national and European authorities to appropriate levels of detail and based on the sub-classifications of construction and demolition waste given in paragraph 3.1.9. The development of these targets should be based on what is technically feasible using Best Available Techniques Not Entailing Excessive Costs (BATNEEC), modified to take into account of:*

(i) the benefits that will accrue from recovery;

(ii) quantities arising;

(iii) environmental impact of treatment and disposal;

(iv) local geography,

(v) local economic circumstances;

(vi) technological and cultural circumstances.

3.5.9 The Group considers that waste management planning authorities should be encouraged to optimize the environmental performance of their waste management planning: The use of life cycle analysis methodology on the waste management elements of the plans - and not on the original materials or products - may be helpful in this regard. In this regard the Project Group supports the development of 150 Standard ISO/CD 14040 Life Cycle Assessment - General Principles and Practices, presently being prepared by ISO Committee TC207.

3.5.10 **Recommendation No.18** *[S9.3]: - Member States should encourage waste management planning authorities to adopt life cycle analysis methodology in their waste management planning.*

3.5.11 In order to maintain the momentum of the proposed Strategy, and to provide a consistent source of base data, the Group considers that a timetable and guidelines on reporting should be provided for Member States and their waste management authorities.

7.1.12 **Recommendation No.19** *[S5.7, S9.3]: - Member States should be required to report on the issues listed below by the year 2000;*

(i) the existing levels (tonnages/annum) of construction and demolition wastes;

(ii) best estimates of future levels (tonnages/annum) of construction and demolition wastes;

(iii) national targets for recovery and disposal (and hence by deduction - prevention) set for periods (measured from the year 2000) of:

(a) five years;

(b) en years;

(c) the long term (when recovery and disposal are considered to have been 'optimized').

3.6 **Qualifications**

3.6.1 The Project Group understands that CEN/CENELEC are presently producing standards for the qualifications of construction enterprises. These standards are intended to cover organizations and enterprises engaged in all the construction activities set out in Annex II to Council Directive 93/37/EEC concerning the coordination of procedures for the award of public works contracts. These include construction, renovation and demolition works.

3.6.2 The Project Group supports the Commission and CEN/CENELEC in the preparation of the proposed qualification systems.

3.6.3 The Project Group notes that it is a requirement of European Union policy that environmental issues are considered and integrated into the development of all Community policies. In this regard the Group consider that it would be appropriate for waste management issues to be specifically addressed in the preparation of the qualification systems for construction enterprises.

7.1.12 **Recommendation No.20** *[S7.1]: - The European Commission should seek to ensure that the standards on the qualification of construction enterprises presently being prepared by CEN/CENELEC satisfactorily address:*

(i) those organizations and enterprises engaged in activities producing construction and demolition wastes; and,

(ii) the associated waste management issues.

3.6.5 The Project Group notes that the qualification system being developed by CEN/CENELEC is voluntary.

3.6.6 **Recommendation No.21** *[S7. 1]: - Member States are encouraged to implement the qualification system for all construction enterprises engaged in activities producing construction and demolition wastes.*

3.7 **Licensing and Permit Systems**

7.1.12 The Project Group considers that licensing and/or permit systems are required to ensure that:

(i) only suitably qualified construction and demolition contractors are engaged in activities generating construction and demolition wastes;

(ii) demolition activities are undertaken in such a manner as to maximize the recovery from, and minimize the disposal of, wastes; and,

(iii) the monitoring and control of waste 'from cradle to grave' is facilitated.

3.7.2 Given the wide range of activities generating construction and demolition wastes, the Project Group recognizes that the detailed requirements for these permits will differ according to the nature of the activity, ie. construction, renovation or demolition, and that some works will involve more than one of these activities.

3.7.3 However, the Project Group is concerned that the proposed requirement for permits, does not impose a disproportionate burden on the construction industry through the introduction of additional bureaucratic procedures. The Group therefore proposes that, where appropriate and practicable, existing permit systems should be modified to address waste management issues.

3.7.4 Similarly, in the interest of minimizing additional bureaucracy, the Group considers that permit systems may include threshold levels for minor works provided that alternative controls exist to ensure that wastes arising are suitable managed.

3.7.5 **Recommendation No.22** *[S7.1]: - Member States set up permit systems covering all activities producing construction and demolition wastes. These permit systems should address the differing requirements associated with differing nature of* the *works, namely:- construction, renovation and demolition, and combined works. Separate permit systems for different activities may be appropriate. Thresholds may be adopted to exclude very minor works.*

3.7.6 **Recommendation No.23** *[S7. 1]:- Where appropriate and practicable, the proposed permit systems should be incorporated into, or be an extension of, existing permit systems, for example, construction permits or planning consents.*

3.7.7 **Recommendation No.24** *[S7.1, S7.2]: - Member States include within the permits the requirement that:*

(i) the works are undertaken by suitably qualified contractors (section 3.6 refers); and that the following information is provided with the application for the permit, and used for determining the application:

(ii) an inventory of the expected demolition waste arising on the basis set out in paragraph 3.1.9;

(iii) *the off-site management proposals for the wastes as set out in 3.1.17, quantified by tonnages; and,*

(iv) *at the discretion of the Member State, a historical overview of the use of the building and/or land.*

3.7.8 It is the intention of the Project Group that, in the majority of cases, the application for a construction or demolition permit will be made by the promoter of a construction or demolition project.

3.7.9 **Recommendation No.25:** - *The permit systems for construction and demolition activities should be formulated in such a manner that it is a requirement for the applications for such permits to be made by the promoter of the proposed construction or demolition project.*

3.7.10 It is envisaged that Member States will wish to introduce permit systems at a national level. Notwithstanding this, as it is the view of the Project Group that waste management is most appropriately undertaken at a local level, it is the recommendation of the Group that the granting of permits is devolved by Member States to local administrations.

3.7.11 **Recommendation No.26:** - *[S7.1]: - The permit systems for construction and demolition activities should be formulated in such a manner that the determination and granting of such permits is undertaken by the appropriate local administration.*

3.7.12 The Project Group considers that local administrations will require powers to ensure that waste management within their jurisdiction is undertaken in accordance with their adopted waste management plan.

3.7.13 **Recommendation No.27:** - *Local administrations be permitted to refuse, require amendments to, or place conditions on, such permits if the proposals are incompatible with the requirements of their adopted waste management plan.*

3.7.14 The Group acknowledges that some Member States have already developed sophisticated construction and demolition permit systems.

3.7.15 **Recommendation No.28:** - *The requirements set out in paragraph 3.7.7 should not prevent Member States maintaining alternative permit systems provided that these include the requirements set out in paragraph 3.7.7.*

3.7.16 In addition to the perceived need for permits for activities generating construction and demolition wastes, the Project Group considers that further improvements in waste separation will be achieved if the collection and transportation of construction and demolition wastes is subject to a greater degree of control.

7.1.12 Two systems were identified by the Group as offering the potential to exercise the necessary control. These were:

(i) the licensing of enterprises undertaking the transportation of construction and demolition wastes; and,

(ii) systems for the supervision and control of the transportation of construction and demolition wastes including consignment note procedures.

7.1.13 The licensing system is seen as offering the opportunity to:

(i) lead to improvements in waste transfer and transportation practices (and reduce the environmental impact of these operations);

(ii) clearly identify the responsibility for the wastes; and,

(iii) complete the control of the waste cycle - 'from cradle to grave'.

3.7.19 With regard to the supervision of the transportation of wastes Council Regulation 259/93/EEC has already been implemented with the aim of organizing 'the supervision and control of shipments of wastes in a way which takes account of the need to preserve, protect and improve the quality of the environment'.

3.7.20 Title II of the Regulation sets out consignment note procedures for the notification of the shipment of wastes between Member States for disposal and recovery. Such procedures offer the opportunity for the collection of the data considered necessary to facilitate good waste management planning.

3.7.21 The Project Group considers that, while the principles behind the consignment note procedures are consistent with the requirement to improve transportation practices, the consignment notes proposed under Council Regulation 259/93/EEC are not appropriate to construction and demolition wastes.

3.7.22 Having initially considered the implementation of both licensing and consignment note systems the Group concluded that this approach would be unduly bureaucratic. Accordingly the Group determined that a single system should be implemented.

3.7.23 Two draft recommendations were discussed at length by the Group. These are reproduced below for information.

Recommendation A: - *Member States should set up systems for the licensing of organizations and enterprises undertaking the transportation of construction and demolition wastes.*

Recommendation B: - *Member States should establish appropriate systems for the supervision and control of the transportation of construction and demolition wastes. Such systems should include a consignment note procedure with a requirement for the 'competent authorities' to report on;*

(i) the source, composition and quantity of wastes transported, based on the classifications given in paragraph 3.1.9;

(ii) the distances transported;

(iii) the location and nature of the receiving establishment (paragraph 3.1.17 refers).

3.7.24 Despite extensive discussion of these two alternatives the Group was unable to come to a conclusion as to which of the two options would be the most appropriate. Notwithstanding this the Group has agreed that additional controls on the transportation of construction and demolition wastes are essential.

3:7.25 In the absence of agreement the Group proposes the following more general recommendation suggesting the development of proposals which meet the key objectives set out in 3.7.18.

7.1.12 **Recommendation No.29** *[S7.1]: - The Commission should develop a proposal for a system exercising greater control over the transportation of* ***construction and demolition*** *wastes. This system should:*

(i) seek to lead to improvements in waste transfer and transportation practices (and reduce the environmental impact of these operations);

(ii) clear/y identify the responsibility for the wastes; and,

(iii) complete the control of the waste cycle - 'from cradle to grave'.

4.1 Education and training

4.1.1 The Group considers that the education of the participants in the construction and demolition industries in the need to prevent the generation of unnecessary wastes is a key element in the Strategy.

4.1.2 The Group acknowledges that this will require the adoption of a new approach by designers and specifies. The Group considers that this would be facilitated if educational material was available setting out the philosophy and techniques associated with:

(i) waste prevention orientated planning and design; and,

(ii) recovery orientated construction.

4.1.3 **Recommendation No.30** *[S6.3, S6.4]:- The Commission should set up research projects with the objectives of collecting data on, and researching available and emerging techniques in:*

(i) waste prevention orientated planning and design; and,

(ii) recovery orientated construction, and produce educational material based on its findings.

7.1.12 **Recommendation No.31: -** *Member States should encourage the institutions, educational establishments and professional and trade associations and federations responsible for the education and training of designers and managers of building and civil engineering works to include education and training in, and the adoption of:*

(i) waste prevention orientated planning and design [56.3];

(ii) recovery orientated construction [S6.4];

(iii) the use of life cyc/e analysis techniques to assist in the specification of materials and products [S6.7];

(iv) qualitative prevention [S6. 9];

(v) design for multiple uses [S6.10]; and,

(vi) design for extending the useful and economic lifespan of structures [S6.8].

4.1.5 The Group also considers that the volume of construction and demolition wastes could be reduced if the lifespan of building and civil engineering structures could be increased where a continuing economic use is possible. This will require improvements in management, inspection and maintenance.

4.1.6 **Recommendation No.32** [56.8]: - *Member States should encourage owners and facility managers to implement management, inspection and maintenance measures with the* objective of *increasir7g the economic lifespan of buildings and civil engineering structures.*

4.2 Environmental and technological information

4.2.1 The Group acknowledges that improvements in construction and demolition waste management can be achieved through improvements in the environmental performance of construction products and materials. Similarly the environmental performance of construction activities may be achieved through the provision of improved information to product and material specifies and purchasers.

7.1.12 The Group recognizes the importance of the application of Life Cycle Analysis and the benefits this can achieve. In this respect the Group supports the work being undertaken by ISO in the preparation of:

(i) ISO 14040 Life Cycle Assessment - General Principles and Practices;

(ii) ISO 14020 Environmental Labeling - Basic Principles of all Environmental Labeling;

(iii) ISO 14021 Environmental Labeling - Self Declaration Environmental Claims Terms and Definitions;

(iv) ISO 14023 Environmental Labeling - Testing and Verification Methodologies.

4.2.3 **Recommendation No.33** *[S6.7]: - Construction Product manufacturers and Material suppliers should be encouraged to undertake life cycle analyses of their products and materials in accordance with recognized international siar1dards, and to make the findings available to prospective purchasers and specifies.*

4.2.4 In order to provide a consistent approach to the dissemination of environmental information to designers, specifies and purchasers, the Project Group proposes that construction product manufacturers and material suppliers produce Product/Material Environmental Data Sheets. The Group proposes that the production of these Data Sheets should be voluntary.

4.2.5 **Recommendation No.34** *[S6.7]:- Construction Product manufacturers and Material suppliers should* set up *voluntary schemes for the provision of Environmental Data Sheets. These Environmental Data Sheets should include:*

(i) Product or Material Type;

(ii) Product Description;

(iii) List of constituent materials (NOTE: voluntary disclosure only);

(iv) % of recovered materials (NOrE: voluntary disclosure only);

(v) details of the international, European or national Standards the products/materials comply with;

(vi) European Waste Catalogue category (or categories) for disposal;

(vii) Hazardous waste category (or categories) for disposal;

(viii) Product Return or Collection Arrangements;

(ix) Recovery and Disposal Options:

(a) re-use;

(b) recycling;
(c) incineration with energy recovery;

(d) disposal by incineration without energy recovery;

(e) disposal to landfill by classes (as defined in the proposal for a Council Directive on the Landfill of Waste, ie. hazardous waste, non-hazardous waste or inert waste).

4.2.6 In order to avoid the duplication of effort, and the imposition of unnecessary costs, the Group proposes that, where appropriate, the proposed Environmental Data Sheets can be combined with, or incorporated into, the Safety Data Sheets described in the Annex to Commission Directive 93/112/EC amending Directive 91/155/EEC defining and laying down detailed arrangements for the system of specific information relating to dangerous preparations of Article 10 of Council Directive 88/379/EEC.

4.3 Standards and Quality

4.3.1 The Group considers that uncertainty regarding the consistent quality of secondary materials presents a constraint to the greater use of such materials.

4.3.2 The Group also considers that existing standards for construction products and materials. and codes of practice, can present constraints to the use of secondary materials in construction works.

4.3.3 The Group notes the work of CEN/CENELEC in the development of performance orientated standards, and that their mandates require that standards permit the use of secondary materials. Notwithstanding this the Group recognizes that the transition from existing standards to performance orientated standards is a long term process.

4.3.4 Accordingly the Project Group considers that separate standards for secondary products are not required. However existing standards should be reviewed and revised to ensure that they do not discriminate against the use of secondary materials.

4.3.5 **Recommendation No.35** *[S8.4]: - Member States should mandate their National Standards organizations to review existing national standards and codes of practice, and the Commission should mandate CEN/CENELEC to review existing European standards, in consultation with all interested parties. Where these standards or codes of practice are found to present constraints to the use of secondary materials from construction and demolition wastes, whether directly or by omission, they should be revised by the appropriate standards organization. Member States and the Commission should report on the measures they have implemented to undertake the reviews by 1997.*

4.3.6 The Group also notes that other regulatory instruments and regulations can discriminate against secondary materials. Examples of these include planning controls and building regulations.

4.3.7 **Recommendation No.36** *[S8.4]: - Member States should mandate the appropriate national authorities to review existing regulatory instruments and regulations and revise them where they are found to present constraints to the use of secondary materials from construction and demolition wastes. Member States should report on the measures their national authorities have implemented to undertake the reviews by 1997.*

4.3.8 The Project Group is of the opinion that prospective specifies and purchasers of secondary materials, and products manufactured using secondary materials, could be assured of the quality of the materials or products if the suppliers or manufacturer themselves were able to demonstrate that their products were produced in accordance with strictly controlled quality systems and to recognized international, European or national standards.

4.3.9 Recommendation No.37 *[S8. 1]: - Secondary materials producers, and manufacturers using recovered materials, should be encouraged to seek certification under existing widely recognized Quality Assurance systems (EN29000 - EN29004 inclusive), and to produce their products and materials in compliance with recognized international, European or national standards.*

4.4 Exemplary role of public organizations

4.4.1 The Project Group considers that public organizations have an exemplary role to play in implementing good waste management practices, and developing markets for secondary materials, by demonstrating the application of waste minimization and recovery techniques, and utilizing secondary materials and products in their works.

4.4.2 In this respect the Group suggests that Member States and their 'competent authorities' should identify those activities capable of making the greatest contribution and give priority to action in those areas.

4.4.3 **Recommendation No.38** *[S9.2]: - Public organizations should be encouraged to adopt contract conditions which:*

(i) require the implementation of the Code(s) of Practice described in paragraph 5.2.6;

(ii) accept and encourage the appropriate use of secondary materials;

(iii) dispose requirements for the adoption of waste minimization and recovery techniques in public construction activities or publicly funded projects;

(iv) impose requirements for the use of secondary materials in public construction activities or funded projects

5 CONSTRUCTION AND DEMOLITION SITE MANAGEMENT

5.1 Recovery orientated separation

7.1.12 The Project Group considers that recovery orientated separation of construction and demolition wastes is an essential element in achieving improvements in the recovery of resources from these wastes. The Group has identified a number of measures to achieve this. These are:

(i) the employment of appropriately qualified organizations 3.7.7(i) refers);

(ii) permit systems relating to activities producing construction and demolition wastes (3.7.5 refers);

(iii) systems for exercising a greater degree of control over the transportation of construction and demolition wastes 3.7.16 refers);

(iv) a Code(s) of Practice relating to activities producing and transporting construction and demolition wastes (see section 5.2.6);

(v) improved training of contractors engaged in activities producing and transporting construction and demolition wastes (see section 5.3);

(vi) the implementation of return and collection systems for separated wastes (see section 5.4).

5.1.2 The Group also considers that it is appropriate for waste management 'competent authorities' (or other appropriate administrations) to develop, promote and implement their own recovery orientated separation schemes. Such schemes should be consistent with adopted waste management planning policy.

5.1.3 **Recommendation No.40** *[S7.4]: - Recovery orientated separation should be* encouraged. *'Competent authorities' or other appropriate administrations should be empowered to set up recovery orientated separation schemes where these are consistent with adopted waste management planning policy.*

5.2 Codes of Practice

5.2.1 The Group considers that further improvements to the management of construction and demolition wastes, and to the level of recovery, would be achieved through the development and adoption of voluntary Codes of Practice for activities generating such wastes, it is envisaged that, in many instances, it will be appropriate to include the requirements proposed for inclusion in a Code of Practice for waste management, in existing Codes of Practice.

5.2.2 The Group recognizes that there are a wide range of construction and demolition practices in the Union and that accordingly the most appropriate approach is for Codes of Practice to be developed at a national level within a harmonized framework.

5.2.3 The Group, also recognizes that much of the relevant expertise and experience that will be required to draw up these Codes of Practice is held by the professional and trade associations and federations representing the construction and demolition industries.

5.2.4 **Recommendation No.41** *[S7.1]: - The European Commission should develop a harmonized framework for a Code(s) of Practice covering activities producing construction and demolition wastes.*

5.2.5 **Recommendation No.42** *[S7.1]: - Member States should be encouraged to make arrangemeflts for the development and implementation of the Code(s) of Practice in consultation with the construction and demolition industries. Member States should inform the European Commission of the contents of the Code(s) of Practice.*

7.1.12 **Recommendation No.43** - *The Code(s) of Practice should address the following* issues:

(I) estimation techniques for waste arising (including the identification of *recoverable materials);*

(ii) construction and demolition site organization and management (including the co-ordination of activities and responsibility for on-site waste management);

(iii) pre-demolition removal of recoverable items;

(iv) organized dismantling;

(v) avoidance of the mixing of wastes including separate storage and collection;

(vi) avoidance of the contamination of recoverable and waste materials.

5.2.7 Members of the Project Group note their willingness to assist in the development of the Code(s) of Practice relating to their areas of expertise.

5.3 Training

5.3.1 The Project Group considers that a training program covering on-site waste management and waste transportation, with the emphasis on promoting recovery, should be developed for all contractors engaged in activities producing and handling construction and demolition wastes.

5.3.2 Recommendation No.44 *[S7.1]: - The European Commission should request CEDEFOP to prepare a framework for a harmonized training program on waste management for all participants engaged in activities producing construction and* *demolition wastes. The issues to be addressed by the training program should follow the guidelines for the Code(s) of Practice set out in paragraph 5.2.6.*

5.3.3 Recommendation No.45 *[57.1]: - The training programs proposed in paragraph 5.3.2 should be developed and implemented by the appropriate national authorities, professional and trade associations and federations, and industry as appropriate.*

5.4 Return and Collection Systems

5.4.1 The Project Group considers that manufacturers and suppliers should be encouraged to collect or receive back from construction sites, products or materials supplied by themselves that have become surplus or damaged as an additional service to their customers The Group notes the opportunity for manufacturers and suppliers to utilize existing logistics systems.

7.1.12 **Recommendation No.46** *[S6.6]: - The construction product and material manufacturing and supply industries should be encouraged to set up and participate in 'collect' or 'return' systems for surplus or damaged materials arising at construction sites. Member States should encourage this and inform the European Commission of:*

(i) he actions they have taken; and,

(ii) the systems set up.

5.4.3 The Group also recognizes the contribution that the separate storage and collection of wastes can make in avoiding mixing of wastes and their subsequent treatment and disposal

7.1.13 **Recommendation No.47** *[S6.6]: - Waste collection authorities and the construction and demolition industries should co-operate in the setting up of separate storage and collection systems for construction and demolition wastes. Member States should encourage this and inform the European Commission of:*

(i) the actions they have taken; and,

(ii) the systems set up.

5.4.5 The Project Group notes the potential for conflict between the use of 'collect' or 'return' systems by manufacturers and suppliers, and the investment in recovery by the waste management industry.

5.4.6 **Recommendation No.48** - *The waste management 'competent authorities' of Member States should take account of the contribution that 'collect' and 'return' systems can make to recovery in their waste management planning.*

6 IMPLEMENTATION OF THE STRATEGY

6.1 The basis for the Strategy

6.1.1 In pursuit of the objectives of the Fifth Action Program on the Environment (Towards Sustainability) and the Priority Waste Streams Program, the Project Group has developed a Strategy for achieving the desired improvements in Construction and Demolition Waste Management. This Strategy, which is based on an analysis of all aspects of the construction and demolition sector industries, is set out in the Strategy Document.

6.2 **The development of markets for secondary materials**

6.2.1 Many of the measures proposed by the Group have as their key objective the development of the market for secondary materials. The Group recognizes that ultimately this market will only develop if the economic structure is such that secondary materials are competitive with primary materials.

6.2.2 The Group has concluded that, while there is no single measure which will produce the desired improvements in Construction and Demolition Waste management, there are a range of measures which taken together will produce the improvements sought.

6.2.3 The Group is of the opinion that a systematic approach to the implementation of the proposed measures will greatly assist in the development of the market. To this end the Group considers that Member States should set out their objectives, the measures they propose to implement to meet these, and the program for their implementation, in detailed 'action plans'.

7.1.12 **Recommendation No.49** *[S5.5]: - Member States should develop and publish detailed 'action plans' for the implementation of the strategy for the management of construction and demolition wastes. These plans should set out:*

(i) *their objectives;*

(ii) *their proposals for implementation of the measures proposed; and,* *(iii) the program for the implementation of the measures.*

6.3 **The Strategy as a integrated 'package'**

6.3.1 The Group, acknowledges that the individual measures proposed will impose differing burdens on the different sectors of the construction and demolition industries. However, taken on balance, the Group considers that the measures taken as a whole are equitable and balanced, and will not impose a disproportionate burden on any one sector.

6.3.2 The Group therefore wishes the Commission to take into account its intention that the Strategy and Recommendations should form an integrated and balanced package of measures.

6.4 **The mechanisms required to implement the Strategy**

6.4.1 In considering the mechanisms that may be required to promote improved waste management the Group has taken account of the fact that the management and disposal of Construction and Demolition Wastes has traditionally been undertaken at a local level that this is likely to remain the situation in the future, and that construction and demolition waste management activities are influenced by a wide range of diverse factors which militate against a 'global' approach.

6.4.2 However, in recognition of the need to respect the principle of market transparency, and to assist Member States in the development of the necessary measures, the Project Group considers that a harmonized framework is required at European level to provide a e basis for the implementation of the Strategy.

6.4.3 The Group acknowledges that there may be some areas where this will require new or amended legislation or regulation. In recognition of the diversity of issues to be addressed, the need for some regulation and control of certain activities, and the need to respect the principle of subsidiary, the Group considers that it is most appropriate for detailed legislative acts to be developed and implemented by Member States.

6.4.4 The Group, recognizes that Member States and competent authorities are subject to financial constraints, and that industry seeks to keep its costs to a minimum in order to remain competitive.

6.4.5 The Group therefore considers that, in drawing up its proposals for progressing the implementation of the Strategy and Recommendations, the Commission should seek to minimize the additional bureaucratic mechanisms consistent with those which may be required to implement the proposed measures.

6.5 The Benefits and Costs of the Strategy

6.5.1 The Group considers that it is of fundamental importance to the proposed Strategy to ensure that the costs of the proposals are considered against the benefits that will accrue from their implementation, and that the measures proposed are targeted to maximize the benefits that will accrue from the proposed investment.

6.5.2 In this regard the Group recognizes that environmental costing is not developed to the extent that the application of existing cost/benefit analysis techniques would be appropriate. The Group accepts therefore that to facilitate the necessary decisions subjective judgements will have to be made in some areas.

6.5.3 Such judgements should clearly demonstrate that environmental benefits will be achieved and that the concerns of those participants in the construction and demolition industries affected by the judgements have been taken into account.

6.5.4 **Recommendation No.50** - *The Project Group fully supports the objectives of the Fifth Action Progamme and the Priority Waste Streams Programme. It considers the improvement of Construction and Demolition Waste Management practices to be of fundamental importance. It urges the European Commission to progress the adoption of the Strategy and Recommendations of the Group as a matter of priority.*

7.1.12 **Recommendation No.51.** - *In determining how the Strategy and Recommendations of the Project Group will be progressed the Group wishes the Commission to take into account its conclusions that:*

(i) the proposed measures should be implemented as an integrated package;

(ii) new or revised legislation may be required;

(iii) a *harmonized framework will be required;*

(iv) additional bureaucracy should be kept to a minimum;

(v) the costs associated with the Commission's proposals should be proportionate to the environmental benefits.

7 MONITORING OF, AND FOLLOW UP TO, THE STRATEGY.

7.1 Working Group on Construction and Demolition Waste Management

7.1.1 The Project Group acknowledges the benefit to the development of the Construction and Demolition Waste Management Strategy arising from the involvement of all the participants engaged in, or having an influence on, construction and demolition waste management (paragraph 2.3.1 refers). It supports the Commission in the new approach adopted in the Priority Waste Stream Programme.

7.1.2 In order to maintain the momentum of the Strategy, progress the Recommendations made by the Project Group, and to facilitate monitoring of the progress of the Strategy, the Group considers that the work of the Project Group should be maintained

7.1.3 **Recommendation No.52** *[S5.5]: - A Working Group on Construction and Demolition Waste Management should be set up. The role of this Group should be to:*

(i) disseminate and promote the aims of the strategy and recommendations;

(ii) disseminate information regarding current and emerging good practice in construction and demolition waste management;

(iii) maintain liaison between all participants;

(iv) monitor the progress made in the implementation of the Strategy and the results achieved;

(v) identify the need for further action on the part of the participants;

(vi) to report on its findings.

7.1.4 The proposed Working Group should be representative of all participants engaged in, or having an influence on, construction and demolition waste management. It is suggested that membership of the Working Group could be based on the membership of the Construction and Demolition Waste Project Group.

7.1.5 The Members of the Project Group note their willingness to participate in the work of such a Working Group.

7.1.6 The Group acknowledges that it will be necessary to strike a balance between achieving the widest possible representation and ensuring that any Working Group remains manageable and effective.

7.1.7 **Recommendation No.53** - *The European Commission should consider how the proposed Working Group on construction and Demolition Waste Management should be constituted in order that it is representative of all the actors in the construction, demolition and waste management sectors.*

7.1.8 The Project Group considers that it would be appropriate for meetings of the proposed Working Group to be held annually. For such meetings to be productive, appropriate preparation, management and reporting should be provided. The Group considers that this should be funded by the European Commission.

7.1.9 It is envisaged that a similar procedure to that adopted by the Construction and Demolition Waste Project Group would be implemented for the preparation of recommendations of the Working Group to the European Commission on future action. These would be recorded and reported (by the organization responsible for the management of the meeting) on the basis of the Working Groups' discussions.

7.1.10 **Recommendation No.54:** - *The Working Group should meet annually. The European Commission should fund the provision of:*

(i) the preparation, management and reporting of the meetings; and,

(ii) the venue.

7.1.11 In undertaking the roles set out for the Working Group in paragraph 7.1.3 the Project Group envisages that the annual meetings will involve reporting on progress on technical and administrative matters by all members, and the development and agreement of detailed action plans for progressing and developing the Strategy.

7.1.12 **Recommendation No.55:** - *The Working Group meetings should involve members in:*

(i) reporting in writing in advance of the meetings on:

(a) their organizations progress over the preceding year;

(b) any problems encountered in implementing the strategy;

(c) proposals for future action;

(d) draft action plans for the coming year; and,

(ii) attending the Working Group meetings to

(a) discuss the above; and,

(b) *agree future recommendations to improve construction and demolition waste management.*

APPENDIX I:

INTERNATIONAL EXPERIENCE INFORMATION

THE INTERNATIONAL EXPERIENCE THE CONSTRUCTION AND DEMOLITION WASTE STREAM IN A INSTITUTIONAL, THECNICAL AND SCIENTIFIC CONTEXT

The objective of this Appendix is to present an overview related with knowledge of the most important world Institutions as well as other countries in the practical, academic and scientific approach to this construction and demolition waste stream. Some of this work has been done in the Chapters when referring the knowledge and experience in the specific areas studied in this dynamic context. The objectives and the work done by some international organisations which belongs to the United Nation (UN), the Organisation for Economic Co-operation and Development (EOCD), European Union (EU) as well as the expertise from other countries out of Europe. These are the examples: USA, Canada, Japan and also the Australian experience. The Europe countries construction and demolition experience is only significant in the European Union member states and in this point of view was appropriated highlighted with the experiences from Denmark and Netherlands as countries with significant results in this waste stream reuse and recycling, followed by Germany, but also United Kingdom, France, Belgium and other countries' experiences whenever advised.

Also the knowledge and the work done by some professional and sectorial associations in waste management area as well universities, research centres and other credible organisations with knowledge in this field are presented. This will be developed with the information related with the work done in the context of the research and according the information available.

European Union Policy and Strategy

The European Union has grown greatly in terms of the area it covers now, numbers fifteen member states in its political significance and its institutions. In the beginning with the Treaty of Rome' signature on 25th of March 1957, which instituted the European Union Community (EEC) they were six members (Germany, Belgium, France, Italy, Luxembourg and the Netherlands). In 1972 Denmark, UK, Ireland and Norway had jointed this group. In 1981 Greece, and 1986 Portugal and Spain. The EU Member States grew once again with the entrance of Austria, Finland and Sweden in 1995 the group had become fifteen Members, fifteen different nations determined to shape their future closely together (Fontaine 1996).

Where early post war proposals for European Union at stroke of a pen failed, Jean Monnet (1888-1979) and the French Foreign Minister Robert Schuman's (1886-1963) pragmatic approach succeeded "A united Europe will not arise overnight or in one grand design. It will be built on practical achievements, creating at first *de facto* interdependence" Schuman declared. (Nunes 1994) The founding Treaties have been revised three times:

- In 1987 with the Single Act.

- In 1993 with the Treaty on European Union.

- In 1997 with the Treaty of Amsterdam.
- In 1998 with the Treaty of Mastrich.

The ultimate goal of the European Union is "an ever closer union among the peoples of Europe, in which decisions are taken as closely as possible to the citizen", the objective is to promote economic and social progress which is balanced and sustainable, assert the European identification on the international scene and introduce a European citizenship for the nationals of the member states. The EU main objectives for the coming years are:

- The implementation of the Treaty of Amsterdam, which contains new rights for citizens, freedom of movement, employment, strengthening the institutions.
- Enlargement of the EU, to take in the applicant countries from central and eastern Europe as mentioned in (Agenda 2000)
- The launching of the Euro currency.

The EU was created to give expression to an ever closer Union of European Nations. The Union's responsibilities have broadened, the institutions have grown larger and numerous. In its first 20 years, the Commission would propose, the Parliament would advise, the Council of Ministers would decide and the Court of Justice would interpret. In the last twenty years, the Parliament has become directly-elected and acquired new powers, and the European Court of Auditors has arrived on the scene, the European Investment Bank has emerged as a major source of finance for economic development. The Economic and Social Committee has testified to the value of debate and co-operation between the economic and social partners and, most recently, the Committee of the Regions has been set up to advance regional interests and diversity.

European Union Directives and other Regulations

In which concerns with the EU environment legislation its important to say that since the EEC treaty, it has been established different requirements for the coming in force of different types of EU legislation as follows:

- Regulations enter into force on the date specified in them or, lacking that, on the twentieth day following their publication in the Official Journal of the European Union.

- Directives and decisions must be notified to those to whom they are addressed and take effect upon such notification. These notification dates are indicated in the footnotes. Directives often give a deadline by which the member states must have implemented them.

- International treaties come into force when they have been ratified by a certain number of states; the dates upon which such treaties came into force in the EU are indicated above.

EU competence regarding the environment, are delegated to it under Treaties, which define areas of competence where the EU has the exclusive power to determine policy and those where it shares competence with member states. Other areas by definition remain within the competence of the member states. The environment is an area of shared competence, as are external relations. Member States are free to adopt legislation in the absence of EU legislation, but where the EU has acted, its legislation is supreme and binding on both past and future member state actions.

The EU can and does actively participate in the preparation of internal conventions on the environment and in their implementation. The Court of Justice has upheld the direct effect of international agreements to which the EU is a party. EU regulations, decisions and directives are enforced in national courts if the obligation at issue is expressed in a sufficient precise and unconditional way.

In terms of types of legislation the EU can adopt:

- Non-binding recommendations and resolutions

- Regulations that are bindings and directly applicable in all member states.

- Decisions that are directly bindings on the persons to whom they are addressed, including member states, individuals and legal persons

- Directives which must be implemented by the laws or regulations of the member states within a designed time limit (normally 18 months to a two years)

The EU Treaty (more appropriate the EEC treaty) establishes different requirements for the coming into force of different types of legislation:

- Regulations enter into force on the date specified in them or, lacking that, on the twentieth day following their publication in the Official Journal of the EU

- Directives and decisions must be notified to those to whom they are addressed and take effect upon such notification. Directives often give a deadline by which the Member States must have implemented them

- International treaties come into force when have been ratified by a certain number of States.

In which concerns to the evolution of EU environmental protection policies, these were more stressed when the global dimensions of environmental pollution were becoming apparent in 1972. This year was the year of the United Nations Stockholm Conference on the environment and European Community adopted its first five year Action Programme (1973- 1977) (MHOP 1978), setting out the principles and priorities that would guide its policies in the future.

The first and second Environmental Action Programme (MHOP 1987) set out detailed lists of actions to be taken to control broad range of pollution problems. Eleven principles were listed, which have remained valid in subsequent action programmes:

1. Prevention is better than cure. This principle has become paramount under the fourth environmental action programme.

2. Environmental impacts should be taken into account at the earliest possible stage in decision-making.

3. Exploitation of nature, which causes significant damage to the ecological balance, must be avoided.

4. Scientific knowledge should be improved to enable action to be taken.

5. The "polluter pays" principle, that is that the cost of preventing and repairing environmental damage should be borne by the polluter.

6. Activities in one Member State should not cause deterioration of the environment in another.

7. Environmental policy in the Member States must take into account the interest of the developing countries.

8. The EU and its Member States should promote international and world wide environmental protection through international organisations.

9. Environmental protection is everyone's responsibility, therefore education is necessary.

10. Environmental protection measures should be taken at the most "appropriate level", taking into account the type of pollution, the action needed, and the geographical zone to be protected. This is known as the "subsidiarity principle".

11. National environmental programmes should be co-ordinated on the basis of a common long-term concept and national policies should be harmonised within the EU, not in isolation.

The third Environmental Action Programme (MHOP 1978) adopted in 1983, tried to provide an overall strategy for protecting the environment and nature resources in the EU. It shifted the emphasis from pollution control to pollution prevention, and broadened the concept of environmental protection to include land use planning and the integration of environmental concerns into the EU polices. The areas affected include the funds for agriculture activities, regional economic development, and aid to Africa, Caribbean and Pacific nations under the Lomé Convention.

The fourth Environmental Action Programme (1987- 1992) (EC 1992b) sough in part to give substance to the new obligations for integration on the environmental dimension into other EU policies by emphasising four areas of activity:

1. Effective implementation of existing EU legislation.

2. Regulation of all environmental impacts of "substances" and "sources" of pollution.

3. Increased public access to and dissemination of information.

4. Job creation.

The fifth Environmental Action Programme "Towards Sustainability" (EC 1992b), the EU Programme of Policy and Action in relation to the Environment and Sustainable Development has been referred in the previous Chapters. Selecting five targets sectors as industry, energy, transport, agriculture and tourism, and seven fundamental environmental themes under attention. They are climate change, acidification and air quality, protection of nature and biodiversity, management of water resources, the urban environment, coastal areas and waste management. This programme supported in a prevention attitude, has been preparing a new strategy for the environment and sustainable development of the communities.

In terms of legislation concerning waste it could be presented the following:

- Council Directive 75/439/EEC – Waste Oils
- Council Directive 75/442/EEC – Waste Framework
- Council Directive 76/403/EEC – PCB and PCT
- Council Directive 78/176/EEC – Titanium Dioxide
- Council Directive 78/319/EEC – Toxic and Dangerous Waste
- Council Directive 82/883/EEC – Titanium Dioxide
- Council Directive 84/631/EEC – Transfrontier Shipment
- Commission Directive 85/469/EEC – Transfrontier Shipment
- Council Directive 85/339/EEC – Beverage Containers
- Council Directive 86/278/EEC – Sewage Sludge
- Council Directive 89/368/EEC – New Municipal Waste Incineration Plant
- Council Directive 89/429/EEC – Existing Municipal Waste Incinerators
- Waste Management Strategy

- Council Directive 90/656/EEC – Transitional Measures in Germany

- Council Directive 91/271/EEC – Urban Waste Water Treatment

- Council Directive 91/156/EEC – Framework Directive on Waste

- Council Directive 94/62/EEC – Packaging Directive

Studies and reports produced on Construction and Demolition waste stream under the EU strategy

The studies and reports referred in this Section correspond to the most significant works on integrated solid waste management but focused on construction and demolition waste stream. A survey from the studies and reports done in the EU member states from the (Morgan and Argus 1995) The findings of a study undertaken by Environmental Resources Limited (ERL 1980) conducted under a European Community contract with the title "Demolition Waste" was published in 1980. This study presented for the period 1976 to 1978 an estimated average annual Construction wastes of 85.5 millions, and 72.1 million tonnes of Demolition wastes for the then nine EC member states. Including the waste from renovation work the study came to total arising of 157.9 million tonnes of construction and demolition waste (Morgan and Argus 1995).

A study done for the EC on the harmonisation of waste statistics contains a first set of statistics on annual waste arising and disposal quantities in the EC member states during the 1980 decade. This study, reported in "Compilation of Community Statistics on Waste" by ERL/ARGUS (1992), contained an estimate of construction and demolition waste generation of about 270 million tonnes for the twelve member states, with the exception of Portugal and Greece, prior to the entry of Austria, Finland and Sweden into the Union.

A study carried out by the European Demolition Contractors (EDA) (EDA 1992) in 1990, sets out an overview of construction and demolition waste in nine member states, whereby Portugal, Luxembourg and Greece were not included. Total construction and demolition waste was estimated at 180.2 million tonnes. The same study predicts a total construction and demolition waste generation of 216.1 million tonnes in the year 2000, with 175 million tonnes coming from demolition work and 41.1 million tonnes coming from construction. In 1991, a study from the Danish consultant company DEMEX together with the International Solid Waste Association (ISWA) calculated in 1991 a total amount of building waste in the EC of 175 million tonnes per year. This was based on a population of about 350 million and an average production of building waste of 500 kg per inhabitant per year.

Other source (EEC REWARD programme) estimate annual construction and demolition wastes arising in different EC countries to range between 0.4 and 0.8 tons per inhabitant per year. It is estimated that without increased levels of prevention and recovery, construction and demolition waste generation will reach in EC an average of 1 tonne per inhabitant per year by the year 2000. The studies under the programme has shown that the waste production per inhabitant in the northern member states, with the exception of Ireland, is significantly higher than the southern member states.

The work done and presented to the EU DGXI at October 1995 (Morgan and Argus 1995) with its 55 Recommendation present on Part 3 as it has been expressed on this theses only in 1998 seems to have a significant sequence. In an interview published in 1996 in Warmer Bulletin with that date, DG of DGXI Mr. Ludwig Kramer (Warmer Bulletin n° 50 1996) about the priority waste stream initiative gives some illumination about the situation. His words were: " We have no intention for the moment to continue the Priority Waste Stream initiative. Because our experience was not so positive, we are unconvinced it is a workable option. This would not exclude the possibility that, in an individual case, we would look at a single waste stream and then tackle that. The reason for not going ahead with the process is that we do not seem able to get all interested associations and groups around a desk. We do not seem to get all interested parties to agree on progressing in environmental protection or in waste management objectives, and we are not sure that such a commitment would stand afterwards."

Only in 1998 another document named "Construction and Demolition Waste Management Practices and Their Economic Impact", from Symonds Group Lta, was produced by request of EU DG XI.E.3 (Symonds et al. 1999). The document highlights data on construction and demolition waste arising and measures which Influence their Management. The document sets out the findings to date of the EC study "Waste Management Practices and Their Economic Impacts" with regard to construction and demolition waste arising and measures which influence their management. It is presented in four sections as follows:

- Summary Table: Best estimates for construction and demolition waste arisen
- Construction and demolition waste arising and their uses and destinations
- Summary of measures used to influence the management of construction and demolition wastes
- Measures which influence the management of construction wastes

It is expected that this report represent the returning to developing work towards a new EU strategy in this waste stream with the consideration of the differences between member states but with all the actors involvement and participation.

Organisation for the Economic Co-operation and Development guidelines (OECD)

The forerunner of the Organisation for the Economic Co-operation and Development (OECD) was the Organisation for European Economic Co-operation (OEEC), which was formed to administer American and Canadian aid under the Marshall Plan for reconstruction of Europe after the second World War. Since it took over from the OEEC in 1961, the OECD vocation has been to build string economies in its member countries, improve efficiency, hone market systems, expand free trade and contribute to development in industrialised as well developing countries. After more than three decades, the OECD is moving beyond a focus on its own countries and its setting its analytical sights on those countries-today nearly the whole world – that embrace the market economy.

The organisation is, for example, putting the benefit of its accumulated experience to the service of emerging market economies, particularly in the countries that are making their transition from centrally-planned to capitalist systems. And it is engaging in increasingly detailed policy dialogue with dynamic economics in Asia and Latin America. But its scope is changing in other ways too. The matrix is moving from consideration of each policy area within each member country to analysis of how various policy areas interact with each other, across countries and even beyond the OECD area. How social policy affects the way economies operate, or how globalisation will change the world's economies. This change could achieved by opening new perspectives for growth, or perhaps trigger resistance manifested in protectionism.

As it opens to many new contacts around the world, the OECD will broaden its scope, looking ahead to a post industrial age in which aims to tightly weave OECD economies into a yet more prosperous and increasingly knowledge-based world economy. The organisation has been called a monitoring agency, a non academic university and so may others designation where it has elements of these characterisations captures the essences of he OECD. It groups 29 members in an organisation that, most importantly, govern a setting in which to discuss, develop and perfect economic and social policy.

They compare experiences, seek answers to common problems and work to co-ordinate domestic and international policies that increasingly in today's globalised world. The core of original members are located in Western countries of Europe and North America. Next came Japan, Australia, New Zealand and Finland. More recently, Mexico, The Czech Republic, Hungary, Poland and Korea have joined to OECD (OECD 1998).

The experience from other European Union countries

In sequence of it has been written in Chapters in this Section it as mentioned the experiences of five countries between others which has significant knowledge and expertise in this construction and demolition waste stream. Denmark, the Netherlands, Germany, United Kingdom, France and Belgium. Of course there are others as the Nordic countries, Austria, Switzerland, Spain and certainly others with work done in this field, but according the work published and known it seems correct to highlight the first six countries mentioned. Denmark as it was mentioned, must be the European country with a most advanced construction and demolition waste stream policy and results. For example, according (Jakobsen 1998), the target for recycling of construction and demolition waste in the year 2000 is 80 %, which is already been reached in 1996 with 89 %. This advance is significant comparing the target presented in Waste Management in Denmark from the (MEE 1996:5) were it was presented a construction and demolition recycling target of 60 % for the year 2000. According to the authors view (Jackobsen 1998) the most important tools for the encouragement for recycling of the construction and demolition waste are as follows:

- Taxes on waste deposited on landfills or incinerated and no tax on waste delivered to recycling facility

- Tax on extraction of raw materials

- Government grants to research and development projects and other projects promoting recycling and cleaner technology

- National action plans for recycling and cleaner technologies

- Local Authority plans for handling of disposal of solid wastes, including construction and demolition waste

- Voluntary agreements with producers of construction and demolition waste

Ten years of experience in the promotion of recycling of construction waste is that the most important instruments are:

- The taxes on waste which id deposited or incinerated and not recycled

- Taxes on exploitation of raw materials

However the taxes cannot stand alone and the authors add as a significant contribution the following measures:

- The establishing of national policies and action plans for integrated resources and construction and demolition waste management

- The encouragement recycling initiatives by grants or subsidies

- The implementation of local planning and regulation of raw materials and construction wastes according to the national policies, not necessarily according to the local interests

- To ensure processing capacity of construction and demolition waste throughout the country

- To establish the necessary documentation and standards for use of the secondary raw materials

- To monitor the streams of raw materials and construction waste streams

Many Danish experiences and knowledge in prevention, reuse and recycling could be presented with results under national strategy goals and targets, with positive involvement from the community. Public participation, community participation is a reality in Denmark, which contributes to the results knowledge. One significant experience is the Municipality of Aarhus, strategy and role improving the sorting of waste. A leaflet about what individual citizen, can do further the cause of recycling in Aarhus (The Municipality of Aarhus 1991), reflects also the author experience in local studies from the results from this experience in 1995

In summary it should be highlighted that the Danish recycling effort related to construction and demolition waste has been successful because:

- The effort has been politically driven from highest level

- The effort has been planned and controlled by the Danish Environment Protection Agency by means of action programmes which have been periodically updated

- The effort has been promoted by economic, administrative and technical guidance instruments, which have also been periodically adjusted. In particular, the introduce of disposal fees and local regulations for disposal of the construction and demolition waste have been of great importance for the recycling effort.

- The effort has been integrated and managed as an entity, which means that all interests have been considered and all lines of business have been given the opportunity to participate. By so doing one has avoided conflicts between demolition contractors and raw materials producers for what concerns processing and marketing recycled products.

In The Netherlands just from the National Environmental Policy Plan 2 from 1994 (MHSPE 1994) towards the target groups, the Construction Industry target group has presented as its interest on sustainable buildings and construction has grown in recent years. This is reflected in the issuing of the Declaration of Environmental Targets for Construction and Housing, 1995 (BMM 1995) (MHSPE 1994). Some general guidelines are pointed out at that time, as:

- Information about sustainable buildings must be available and spread

- Co-operation between the various actors involved needs to be improved

- Better dissemination of the information through information campaigns must be developed

- Research into technologies and the recycling of waste in the Construction Industry must be intensified, with publicity results

- The introduction of environmentally friendly products and construction methods onto the market must be stimulated

- Building regulations are being studied as it the scope for embedding the concept of sustainable building in environmental legislation and land use plans.

- Policy co-ordination between the different levels of government will be reinforced.

Also a document from MHSPE (1997) refers that a crucial element in the disposal structure for construction and demolition waste is the separation at source, financial incentives and the sale of the secondary raw materials produced from the waste. The chief product is demolition waste granulate, which is sold as foundation material for road construction and to a lesser degree as a substitute for gravel in concrete.

A study from Hulst (1998) states that the Dutch government has undertaken in most cases a close co-operation with industry, different associations and umbrella organisations as well as many initiatives to stimulate the reuse and recycling of construction and demolition waste stream. The Ministry for Housing Spatial Planning and Environment has published a handbook that provides a number of practical measures and instruments regarding the use of secondary raw materials. Some items covered by this handbook are:

- "Policy Development
- Moments and ways in the building process to stimulate the use of secondary materials
- Checklists with information on secondary raw materials and their different fields of application
- Building specifications regarding the use of secondary raw materials
- Selection of umbrella organisations and building & construction associations with experience and know how in field of secondary raw materials".

Voluntary agreements, a certification system developed by the Dutch association of demolition waste contractors (BABEX), extensive research and develop programmes, taxes in raw materials extraction and a levy system to landfills were fundamental pillars in this policy. The involvement of all the actors in a "joint and long lasting operation" will have stimulate the recycling and reuse, also by:

"- Financially supporting research

- Providing examples by means of demonstrating projects in which secondary raw materials are applied

- Creating legislation which enables the application of secondary raw materials

- Taking care of intensive transfer of knowledge"

Federal Republic of Germany, which is a federation comprising 16 states or Läunder, where the administrative structures vary between individual Läunder. 14.561 German communities from 323 rural districts or no district municipalities and these then form 34 administrative regions. The government tasks in the field of environmental protection are distributed between the three tiers at which action is taken: Federal Government, Läuder and Local Authorities. The legislative competence of the federal Government under the terms of the Constitution (Basic Law) lies *inter alia* in the sphere of waste management (FME 1997).

In order to solve the problems surrounding waste, from the prior decade the German Federal legislation was passed on 27th August 1986 in the form of the Waste Avoidance and Waste Management Act (FME 1993) which considered a special Ordinance on Residual Materials from Construction Work. This administrative long chain does not have been impossibility to improve a construction and demolition policy under the global integrated solid waste management guideline – Waste management, Closing Substance Cycles. According to Ruch and Rentz (1994:363- 372) the Germany waste law from 1994 consider the following categories of building and demolition waste:

- Demolition waste (Bauschutt)

- Waste from excavation sites (Baustellenabfalle)

- Excavation debris (Bodenaushub)

- Road construction debris (StaBenaufbruch)

According to these authors, the goals to 1994 and 1995, on reuse of construction and demolition waste in Germany were presented in Chapters. The figures presented are compatible with the figures presented in the report (Symonds et al. 1999:7) to the EC only in which concerns road construction, or road planing with 80% to 1994, while the other construction and demolition wastes reaches the sum of 49 %. The (FME 1997) refers that in Germany "some 85 millions tonnes of building rubble, road debris and building-site waste materials are generated each year. The Federal Government aims to reduce the quantity of recyclable buildings waste still being dumped and, in the bulk materials sector, to promote high quality recycling in the form of building products.

Today some 31 million tonnes of waste building materials are already being recycled, while about 54 million tonnes are dumped. However recycling is not an option for the approximately 8 million tonnes classified as contaminated. The implementation of the voluntary commitment will mean that up to 23 million tonnes of building waste will be additionally available for use in new building materials.".

Before to express some ideas about environmental concerns and waste management in United Kingdom, some words must be done in order to highlight the importance of the UK Environmental Act 1995. In fact the Environmental Act 1995 (Lane and Peto 1995) is a landmark in the development in the development of environmental law in UK. The creation of powerful, wide-ranging new environmental agencies for England, Whales and Scotland is a central feature of the new legislation. To understand the importance changes and their extensive functions of these bodies and examines their significant powers of conservation and pollution control are also fundamental.

Concerns with the waste management In United Kingdom has been highlighted trough this research with some important reports, where the Waste Strategy for England

and Wales sets out the Government's policy framework for the management of wastes. This strategy for sustainable waste management in England and Wales was sorted out in an important document "Making Waste Work" (Department of the Environment and the Welsh Office1995). The main objectives expressed are:

- "To reduce the amount of waste that society produces.

- To make the best use of the waste that society produces.

- To minimise the risks of immediate and future environment pollution and harm to human health.

- To increase the proportion of waste managed by the options towards the top of the waste hierarchy."

Also important targets were designed as follows:

" – To reduce the proportion of controlled waste going to landfill from 70 % to 60% by 2005.

- To recover value from 40 % of municipal waste by 2005.

- To set a target for overall waste reduction by the end of 1998.

- A range of secondary targets relating to individual wastes streams."

The UK waste management strategy, shows that in 1990 about 435 millions tonnes were produced annually in UK, but only 245 million tonnes of this waste produced is controlled waste, remaining 190 million tonnes in non controlled waste.

Construction and demolition waste stream policy in France, according to one updated document ADEME (1998) the waste stream quantity and quality is presented in Figure 6.2, a result from the medium of the survey done in site works and in relation to the years 1990, 1991 and 1992.

The Annual Report 1996 from the UK Department of the Environment developing the Government's Expenditures Plans 1996- 97 to 1998- 99 (Department of the Environment 1996b:103), also stressed that the Government and the Department continue to promote sustainable waste management, with the emphasis on reduction, reuse, recycling and recovery; to ensure the proper control of waste management, to create and improved framework for the prevention of contamination of land, and for the facilitation of its clean-up. Another objective is to promote higher local environmental quality, with fewer nuisances especially from litter and dogs, and also to protect health from man made and terrestrial radioactivity.

A report to the ISWA working group on recycling and waste minimisation (Cooper 1995), gives a representation idea about the UK position on construction and demolition waste management, stressing the quantitative and qualitative aspects, legislation, recycling, and reuse and at final the UK trends and perspectives. It is possible to summarise the conclusions from the Volume four, where it is highlighted the absence of regulamentation from EU, the delay in the discussion and the implementation of recommendations from the EU construction and demolition working group. It is also strengthen the initial advice that every priority waste stream must be object of a specific Directive. Other conclusions are focused on:

- Insufficient construction and demolition data in terms of their nature and composition.

- The necessity to assume a direction towards the deconstruction instead the demolition attitude.

- The necessity of appropriate Specifications.

- The importance of labour training and costs control.

- The all actors' involvement in construction and demolition waste management policies.

- The construction recycling plants appropriate selection and markets developments.

A regional scheme to the construction and demolition waste management was done and presented by the Alsace region with the participation of actors from Public Administration, Industry, and qualified technicians. The study done under the name of "Rapport de l'Átellier Thématique pour la Valorisation de Déchets en Génie Civil" gave a strong contribution to the diagnosis of the situation and to this particularly experience methodology (PRA/DRIRE 1993). Also the CSTB, by its "Mission des Études Génerales Départment Economie ET Sciences Sociales" has been developing research with some partners mainly with ADEME, about the wastes from construction site (Déchets de Chantier).

A study from the French Ministry of the Environmental in co-operation with ADEME and the French Centre of the External Trade (ME/ADEME/CFCF 1994) gives a global idea about waste management in France and contributes to open the co-operation between public Authorities and enterprises to find common resolutions considerations the construction and demolition waste stream.

In Belgium some work has been done as referred in Chapter 4, and where its important to highlight the role of the Belgian Building Research Institute (BBRI) with is main office in Brussels, one office in Zaventem and a research facility in Limette (DePauw 1994). Research in this specific waste stream in terms of the reuse of demolition wastes as aggregates in concrete, has been done with practical application. This is the case of these secondary aggregate utilisation in the construction of the embankment walls of a new lock with greater capacity, near of the expansion of the Antwerp harbour, was referred by some authors (De Pauw 1994: 388). On Chapter 5 it was referred a study developed by BBRI presented the construction and demolition wastes average composition and sources in Flandres (Simons and Henderieckx 1993:27). Research developed by BBRI (or CSTB) in French, and the Centre de Recherches Routiéres (C.R.R.) had contributed to develop a "Plan Relatif à la Prevention ET la Gestion des Déchets on the Regions de Bruxells- Capital" (IBGE 1993) under the guidance of the Institut Bruxellos pour La Gestion de L'Environment".

The knowledge and role of the United Nations organisation

The name "United Nations" was devised by United States president Franklin Roosevelt and was first used in the "Declaration by United Nations" of January 1942, during the Second World War, when representatives of 26 nations pledged their governments to continue fighting together against the Axis Powers. Officially it came into existence on 24 October 1945, when the Charter was ratified by China, France, the Soviet Union, the United Kingdom, and the United States of America and by majority of other signatories (UN 1995). The purposes and principles of the United Nations are linked with the international peace and security, but also on the co-operation to solve international economic, social, cultural and humanist problems, towards sustainable development. The Charter established six principal organs of the United Nations, as follow:

- General Assembly
- Security Council
- Economic and Social Council
- Trusteeship Council
- International Court of Justice
- Secretariat

Most of the work of the UN, excluding peace-keeping operations, goes into programmes aimed at carrying out the pledge of the Charter to "promote higher standards of living, full employment and conditions of economic and social progress and development". The area, which this research concerns, is inserted in this Economic and Social area, and all the information referenced on the Chapters is from publications, which belongs to organisations under this objectives. Giving practical expression to these broad strategies and concerns, has it was adopted a number of declarations, programmes of action and development strategies, as well as specialised agencies, designed to strengthen international co-operation for development.

This is the example of the United Nations Development Programme (UNDP), World Bank, WHO, UNESCO and UNIDO. On this research there are references from articles, reports, magazines, proceedings and books from these organisations with more emphasis in the UNEP scientific and technical production. This is a result of the work done from the UN Conference on the Human Environment held at Stockholm 1972, and this UN agency was the first based in a developing country. It has its headquarters in Nairobi, Kenya. The historic Vienna Conference on 1983 and the Montreal Protocol on 1987 opened the door to the Earth Summit, the UN Rio Conference. In fact, the role of this agency was reinforced when the UN Conference on Environment and Development, held in Rio de Janeiro, Brazil at 1992, adopted the Agenda 21 (UN 1992a), a comprehensive blueprint for global Sustainable Development.

The UNEP's Global Environment Monitoring System (GEMS) and Global Resource Information Database (GRID), INFOTERRA worldwide network for environmental information, the UNEP's Industry and Environment Office provide between others significant information on these environmental areas. An example of this technical and scientific production is the Technical Publications Series from UNEP and the International Environmental Technology Centre (IETC) (UNEP/IETC 1996). UN trough UN Institute for Training and Research (UNITAR) and UN University have the objective to enhance training, research and knowledge.

Also in the industry area, UNEP has been developing a significant work with the publication of the Industry and Environmental, which is a quarterly review very, focused in these industry and environmental relationship. An example of this work in recycling waste promoting of the waste recycling, with examples in Japan and Brazil (UNEP 1994). In this review is present an article from (Lauritzen1994) highlighting the economics and environmental benefits of recycling waste from the construction and demolition of buildings.

The role of the International Bank for Reconstruction and Development known as World Bank (World Bank 1998), with its main label "A world free of poverty", purposing to reduce poverty and improve living standards thought sustainable growth and investment in people, must be highlighted. Investing in people, protecting the environment, education of young people, strengthening Government Capacity building, promoting economic reform are the principal role of the United Nations economic and financial and financial branch.

Experiences from other countries

In this particularly waste stream it was been referred along the previous Chapters, the experience of other EU countries. The objective of this Section is to summarise the principal experiences from countries out of EU, with significant experience in this waste stream according the main references, which it was considered the CIB and RILEM events and scientific works. After a survey about the principal work done in this specific area it is possible to say that four countries has the main significant experience and knowledge: United States of America (USA), Canada, Japan and Australia.

In which concerns to the United States of America (USA), the attention will be concentrated on the United States Environment Environment Protection Agency

(USEPA), the national environment authority and on the Solid Waste Association of North America (SWANA) which is the national member of the International Solid Waste Association (ISWA). The USEPA mission is to protect human health and to safeguard the natural environmental air, water and land, upon which life depends. USEPA's purpose is to ensure these objectives, and its EPA Strategic Plan, the blueprint for taking EPA into 21st century (USEPA 1998) and achieving a critical public health and environmental protection for the American people over the next five years, including EPA's mission.

The EPA organisational structure with their thirteen Offices, where in the context of this research must be highlighted the Office of Solid Waste and Energy Response, provides Agency wide policy, guidance, and direction the land disposal of hazardous waste, underground storage tanks, solid wastes management, encouragement of innovative technologies and source reduction of wastes. A lot of very important strategy documents, reports, research programmes, action plans has been developing in the EPA, which is important role is accepted by over the world. Superfund programme is a significant example. An article published in (Warmer Bulletin nº 57 1998) under the title "America turns a corner on waste" gives an up to date information about the results and the near project from USEPA to following the EPA's waste management hierarchy.

There are many research institutes, universities, associations and other organisations in different States in USA, some of them referred in the previous Chapters, with work done on construction and demolition waste stream in a sustainability overview, towards sustainable construction. In this context and in university area it is highlighted the University of Florida and the Center for Construction & Environment (CCE 1998), due its contribution in Sustainable Construction promotion and development. The Center mission is to foster the implementation of sustainability principles into the creation of the built environment internationally, which includes insuring resources such as energy, water, materials and land utilised efficiently as well as renewable and recyclable resources.

The Center between other activities organised in 1994 the First International Conference on Sustainable Construction, the Green Building Materials '96 Conference and the 1st, 2nd an 3td Annual Sustainable Development Seminar Series "Sustainable

Communities" as well as other activities on sustainable development issues. Several Research Institutes, Laboratories and other organisations developed work on these sustainability issues. Between others, the US Army Corps of Engineers (USACE), with its Construction Engineering Research Laboratory has been developed research on Construction area itself and by memorandum of understanding with other institutions as for example the University of Illinois at Urbana-Champaign (UIUC), which was selected between 20 civil engineering schools. Many research projects are available and some was been presented at CIB Conferences, Seminars and workshops.

About Canada it must be mentioned that it is one of the world countries most involved in Environment concerns and sustainable practices. The OECD review assesses Canada's performance in eight different areas as follows. The review is part of the OECD programme, which examines the environmental trends and conditions in Member countries and conducts peer reviews of the progress made in improving them. The different areas analysed are:

- Ecosystem Management, including nature conservation
- Air
- Water
- Waste Management
- Integration of environmental and economics policies
- Forestry
- Energy
- International Co-operation

The OECD report highlights areas where progress has been made in Canada and draws attention to areas where further progress is required. In terms of wastes the report highlights that "is critical the high levels of waste generated in Canada, and points out that it will be difficult for Canada to meet its 50% per cent reduction target by the year 2000" (Environmental Canada 1998). On construction and demolition waste management area some case studies and studies have been developed in many States, which special emphasis according the information available to Ontario. That is the reason why it was chosen the case study about an Ontario deconstruction residential house. The Canadian expert's community has followed sustainability, Sustainable Construction, and this specific overview of construction thinking in deconstruction carefully.

Between others significant construction and demolition projects, the Great Toronto Home Builders Association North York, Ontario, implemented a successful waste recycling programme by setting a reduction goal of 50% by the year 2000 (Tansen and Tansel 1998). The project develops a set of education materials, conducted pilot demonstration projects and established a continuos programme of education for consumers and educational and training for builders. A study from (Finn and Milne 1994) presented in CIB Task Group 8 Conference Building and Environment, develop a framework for a Canadian strategy on construction and demolition and the environment, which is a significant document in this waste stream sustainable management.

In Japan, the Government of Japan Environmental Agency and the Ministry of Heath and Welfare has been developing strong efforts to a eco cycle society as it was expressed Chapter 2, presents the interactions concept. During the twenty-seven years after the establishing of the Environment Agency in 1971, the environmental situation at both global and national level has undergone substantial changes, with special emphasis since the 1992 UN Earth Summit held in Rio de Janeiro, Brazil. In Japan the Basic Environmental Law setting out basic principles and directions for the making of environmental policies was enacted in November 1993. Before this basic Law, the Environmental Law for Pollution Control from 1967 and Nature Conservation Law from 1972 has been become more insufficient to deal with problems as global environmental problems and pollution in its multiple perspectives.

In the sequence of the new 1993 Environmental Law and following the Agenda 21 recommendations it was approved in 1994 a Basic Environmental Plan (JEA 1998).

This Plan has the intention to clarify the needs to be done by the beginning of the 21st century in terms of national and local government, corporate and individual actions. The Plan sets the following four long-terms objectives:

- Sound Material Cycle
- Harmonious Coexistence
- Participation
- International Activities

The Japanese Waste Management and Public Cleansing Law (Waste Management Law) enforced in June of 1995 (WMPCL 1995) gives special emphasis in the Waste Management Plans, strongly focused on promotion of waste reduction, and as fundamental tools to achieve the national goals and targets. In terms of waste generation, both MSW and Industrial Wastes are showing a slight decrease from the years 1993 and 1992 respectively (WARF 1997:1). Construction and demolition represents in 1993, 15.5 % of the total of the Industrial wastes generated. Also in 1993 the number of recycling facilities in the waste stream were 597, where 39 % were crushing type, 8.4 compacting type and 52.4 % combined type.

The difficult to manage in Japan this waste stream was stressed by (Hirai and Hashizume 1996) in these words "Mayors of municipalities are entitled to require co-operation of enterprises which manufacture, processes, sell or otherwise handle products containers, etc, to facilitate proper treatment and management of wastes. The Japan Society of Waste Management Experts (Hirai and Hashizume 1996) has been also developing research and supporting demonstration projects in the waste stream, face its representative weight in the global Japanese waste management

The large incineration plants solutions both in MSW and Industrial wastes, 1854 units in MSW which represented in 1993, 74.3 % of the total MSW production, and 64% in terms of Industrial Waste (WARF 1997: 3). This leads to a Slag production of 7.8 %, which also has been utilised, after the development of specific research, in the base and sub-base of roads pavements. Universities and research institutes, as the Building Research Institute from the Ministry of Housing has been the main actor in the research developed in this construction and demolition waste stream. This is highlighted in the selection of a case study, Tokyo residential building demolition and the lessons achieved from this practical experience. The RILEM Tokyo workshops, as it could be highlighted the 1995 workshop on Disposal and Recycling of Organic and Polymeric Construction Materials, organised by RILEM, Architectural Institute of Japan and Japan Technology Transfer Association is a significant example. The involvement of some Japan universities as the Nihon University which a co responsible of the Proceedings edition is a result of the closely involvement of the academic world in the maintenance and development of the bridge with the fieldwork.

In Australia the Environment Protection Authority by its Department of Environmental Resources has been defined National Strategies in the Environmental and sustainable development which is compatible with the Australia high environment ranking and quality. The Government through its Department of the Environment and Heritage (Environment Australia 1998) is developing in the national interest, a proper recognition of environmental, social and related economic values in government decision- making process, program delivered and communication. Ensuring that Government has available to do it reliable information, advice and delivery mechanisms develop these.

Some universities, which Griffith University Faculty of Environmental Science in an example, could be presented as a fundamental contribution to this environmental quality level. Griffith University is the home of Australia's first environmental studies program (SWANA 1998). The Faculty of Environmental Sciences is the largest group of environmental professionals in Australia, and amongst the largest in the world, has been a leader in the training of environmental professionals. Also currently research in Australia at Deakin University is investigating the possibility of addressing waste reduction at the design and procurement stages of the building process (Reuse Technology Inc. 1998), under the slogan "Progress Today with Respect for Tomorrow".

Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), which is an independent statutory authority, constituted and operating from

1949, with its total 7497 staff have been giving a strong contribution in research and practical improvements towards sustainability (CSIRO 1998). Its about 3000 scientist, working in laboratories and field stations around Australia covering a broad range areas of economics to the environmental issues has been also developing significant work towards sustainable energy and sustainable construction.

Waste minimisation in the Construction Industry, has been developed in several dimensions with practical application in recycling plants, but also developing case studies research with this objective. Recycling and Resource Recovery Council (RRRC) from the Construction Industry waste has contributing to case studies development (Environment Australia 1998) with some contractors. One of them Fletcher Construction developed two similar case studies at Melbourne with significant results, which are world spread by the Environed Australia, a Cleaner Production Case Studies Directory, increasing these sustainable practices.

The expertise from the CSIRO scientists has been referred when the presentation of the research about embodied energy in buildings and materials (Tucker and Treloar 1994: 183- 191) as well as the work done by Salomonsson and Treloar (1994: 343- 352) on recycling of materials in Building Construction. In terms of construction and demolition waste stream research, researchers from CSIRO particularly the Building Construction & Engineering has been presented in all the significant world environmental events, which must be highlighted in this context the Conferences, seminar and workshops from RILEM and CIB.

The knowledge from some important technical and scientific international organisations

Facing the impossibility to mention all the important technical and scientific organisations with significant knowledge and expertise in this field, come of them universities with research centres, public research centres but also some private and independent research and scientific centre, the option was to select these ones, which are more related with the Portuguese reality. In fact this subjective and discussing option but it seem the most pragmatic due the Portuguese situation in this construction and demolition waste stream.

International Union of Testing and Research Laboratories for Materials and Structures (RILEM)

RILEM, the International Union of Testing and Research Laboratories for Materials, is a non profit-making, non governmental technical association whose vocation is to contribute to progress in the construction sciences, techniques and industries, essentially by means of the communication it fosters between research and practice. RILEM's activity therefore aims at developing the knowledge of properties of materials and performance of structures, at defining the means for the assessment in laboratory and service conditions and at unifying measurement and testing methods used with this objective. In summary the purpose of RILEM is to collect, produce and disseminate knowledge and information (RILEM 1998) as an essential contribution to:

- Research on the properties and performance of materials in structures, under laboratory and service conditions

- Unification of test methods and development of new experimental procedures

- The practical application of research results in building and civil engineering

Under this purposes the RILEM technical programme includes six main items as follow:

- Low cost construction
- Recycling of building and waste materials
- Performance, maintenance and repair of building materials and structures during the service life
- Improved and controlled manufacture of materials of materials and structures
- Impact of building materials on the environment and on the health of human beings
- Updating of testing methods

The RILEM organisational structure are carried out by three administrative bodies: the General Council, the Bureau and the Secretariat General, and more three technical bodies the Management Advisory Committee, the Technical Advisory Committee and the Co-ordinating Committee. The main service, which RILEM provides, is the information exchange and collaborative work between experts and Institutions at an international level. Conferences and workshops organised or sponsored by RILEM aim to collect produce and disseminate knowledge and information as an essential contribution to:

- Good performance and economy of materials used in building and civil engineering
- Research on the properties and performance of materials in structures, under laboratory and service conditions
- Unification of test methods and development of new experimental procedures

Also RILEM meetings are the objective to:

- Promote a clear transfer of research into practice, from materials science to material engineering, trough the early participation of industrial and other users; enhancing the transfer of technology from laboratories to industry

- The preparation of short synthesis reports on specific technical subjects, improving technology interchange between industrialised and developing countries

- Strengthening its work in the different regions of the world, through the promotion of effective National and Regional Groups

RILEM has been developing important Conferences, Symposium and Workshops, which has been a supportive literature and source of information in this research. Some technical and scientific events from RILEM were developed with professional, technical and scientific associations. One example was the Third International RILEM Symposium on Demolition and Reuse of Concrete and Masonry held in Odense, Denmark, organised in co-operation with the Danish Building Research Institute and the RILEM TC-ILI-DRG (RILEM 1993). Other significant examples in this worldwide RILEM expression are two events held at Japan in 1988 and 1995. The first was the Second International Symposium on Demolition Methods and Practice

(RILEM 1988) and the second the International RILEM Workshop on Disposal and Recycling of Organic and Polymeric Construction Materials (RILEM 1995). RILEM Publications, Proceedings and Reports are available from RILEM Publications SARL and from E & FN Spon.

International Council for Building Research Studies and Documentation (CIB)

The International Council for Research and Innovation in Building Construction (CIB), which CIB is the acronym of the abbreviated French number name "Conseil International du Bâtiment". In the course of 1998 the abbreviation has been kept but the full name changed into the British version. CIB was established in 1953 with the support of the United Nations, as an Association whose objectives were to stimulate and facilitate international co-operation and information exchange between governmental research institutes in the building and construction sector, with an emphasis on those institutes engaged in technical fields of research. At that time an implicit objective was to help rebuild the European infrastructure for building and construction research following the ravages of the Second World War (CIB 1998).

At the start, 43 research institutes were members of CIB and by far the majority of these were European. And just as in the programmes of these institutes at that time, so in the CIB programme there was a strong emphasis on technical topics. At present about 500 organisations are members and about 5000 individual experts participating in over 50 CIB Commissions. These extend over the whole area of building and construction research innovation. Among the CIB member organisation are it is possible to find almost all the major national building research institutes in the world, as well as many other types of organisations in the building and construction sector. The technical topics are focused in organisation and management, economics of building, legal and procurement practices, architecture, urban planning and human aspects.

The European Topic Centre for Waste European Union (ETCWEU)

The European Environment Agency based in Copenhagen, Denmark has awarded a contract to a consortium that will develop a European Topic Centre of Waste (EEA 1997). The Topic Centre which is going to house the waste experts of Europe, will be run by a joint venture between the Danish Government and the Environmental Protection Agency Copenhagen (EPAC), in co-operation with a number of international partners, and both the EU Commission, EUROSTAT and the European Environmental Agency will benefit from the new centre. The aims of the Centre, which has a budget of more than ECU one million over the next three years, are:

1 – Examination of existing data and assessment of their comparability

2 – Elaboration of prognosis and waste scenarios

3 – Mapping of emission from waste management facilities

4 – Development of a database about waste treatment plants

According to the Warmer Bulletin n° 56 (1997:3,22,23) the consortium is a partnership led by the Danish EPA and the City of Copenhagen EPA, together with the Hazardous Waste Agency of Baden-Württemberg, Germany, Ireland's EPA, the Austrian Federal Agency and the Waste Agency of Catalonia, Spain. Meanwhile other source (Uhre 1998: 6,7) refers that besides the Danish Government, the Environmental Protection Agency Copenhagen (EPAC), the other partners are the Austrian, The Irish and the Catalonian Environmental Protection Agencies together with the German consultant SAA from Baden-Württemberg.

The EU member States has been developing a joint programme towards the creation of European Topic Centre (ETC), and they have recently established an ETC for waste. The waste statistics preparing a common European strategy becomes a priority, and now policy makers realise that waste policy is not working well. According the Agency (EEA) executive director Mr. Domingo J. Beltrán in September of 1997, sharing information helps us all share a common view, to co-operate and solve common problems. This ETC for waste are just at beginning but it will assemble a Centre of excellence in Member States to develop information to guide policy development in a more efficient way.

British Research Establishment (BRE)

British Research Establishment (BRE) is the UK leading Centre of expertise on Building and Construction, and the prevention and controls the fire. Its expertise developed over 76 years, is available to all in the Construction and associated Industries, from multi-national companies and government Departments to individual designers, builders and homeowners. BRE has in the moment around 350 professional research and consulting staff who operate within Centres of excellence focusing on core capabilities.

BRE is owned by the Foundation for the Built Environment, a non-profit distributing body that purchased BRE from the government in March 1997. This ownership lets the Centre to remain independent from specific interests, safeguarding its reputation for objective and impartial research and advice. The Foundation for the Built Environment is a non profit-distributing body having the legal status of a Company Limited by Guarantee (CLG). It was formed by members of BRE management to provide independent, non-sector ownership for the Building Research Establishment when BRE was transferred to the private sector in March 1997 (BRE 1998).

Building Research Establishment Ltd is a wholly owned subsidiary company of the Foundation. This ownership structure was created in order to guarantee BRE's independence of specific commercial interests and to protect its reputation for objectivity and impartiality in research and advice. The members of the Foundation are firms, professional bodies and other organisation drawn from a wide range of construction, building owners and associated interests. Some university (14) with prominent built environment research groups are also Members. They are:

- Aston's University

- Cambridge University, Martin Centre

- City University, School of Engineering
- CPBEM
- Cranfield University
- Heriot-Watt University
- Imperial College
- University of Dundee
- University of Nottingham
- University of Reading
- University of Salford
- University of Sheffield
- University of Stathclyde
- University of Ulster
- University of Wales, Bangor

The members of the Foundation are grouped into six Colleges each representing a specific set of interest as follows:

- Construction professionals
- Contractors
- Suppliers of materials and products

- Housing

- Building owners and managers

- Universities

The Foundation exists "to champion excellence and innovation in the built environment" and it intends to achieve its aims through:

1 – The research, consultancy, and other services provided by BRE

2 – Complementary activities carried out under the Foundation's auspices

3 – Sponsoring relevant research, education, etc. its income coming from the surpluses generated by trading activities (including BRE), donations, investments, etc.

4 – Stimulating debate on challenges and opportunities in the built environment

Centre Scientifique et Technique du Batiment (CSTB) (France)

The Scientific and Technique Construction Centre (CSTB) is a public research organisation with overall budget of approximately 340 million French francs for 600 employers, including 300 engineers and research workers. The Centre undertakes a research programme funded under the auspices of the housing, transportation and space ministry. The objective is to collaborate with the building professionals and products manufactures to improve the collaborates with the building professionals and products manufacturers to improve the overall construction industry quality and competitiveness (CSTB 1998).

CSTB with its heading "Le future en construction", in its words is building the future of the construction industry. Their experts, researchers, engineers and high level technicians backed up by the most advanced equipment and modern technology apply their specialised skills to four fields:

- Research
- Technical Consultancy
- Quality Assessment
- Knowledge Dissemination

The annual budget has broken down as follows:

- 32 % research and development, public funding
- 23 % scientific and technical consultancy
- 36 % evaluation, assessment and certification
- 9 % dissemination o knowledge by publications, electronic publishing and training

The complementary professions and the broad scope of their activities constitute CSTB's comprehensive approach to construction, encompassing the urban context, with its related services and relevant expertise. The organisation comprises a wide range of prominent experts, specialised in building materials and techniques, equipment, safety, thermo logy, acoustics, aerodynamics, lighting, environmental and health issues. Also advanced communications technology, as well as economics and sociology are areas of research. CSTB assist manufactures, building contractors, engineering firms, architects and contracting authorities, as well as advising Public Authorities on technical regulations and construction quality. As a public industrial and commercial corporation, CSTB operates independently of the partners in the building industry, such as construction professionals and manufactures. The Centre has five locations in the country with different technical and scientific responsibilities as follows:

- Paris (head office, documentation centre and library, economic and social sciences)

- Marne-la-Vallé (building technique, thermo logy, equipment and services, environment and health fire safety)

- Grenoble (acoustics and materials)

- Sophia-Antipolis (information and communication technologies, renewable fuels)

CSTB plays a leading role in both European construction and international co-operation and in which concerns to Portugal, the National Laboratory of Civil Engineering has been had along this decades a close technical and scientific natural link with CSTB. The Centre plays also an active role in the computerisation of the building sector and has lead or contributed to major national or European IT/PDT projects such as CD-REEF, which means 22.000 pages of technical documentation accessible on a CD-ROM, BATIBASE with 30.000 construction products stored in a database and made accessible to the public by means of MINITEL, DOCCIME which is a electronic Product data management and also relevant between others the COMBINE which is a DGII sponsored project towards a energy conscious design.

International Solid Waste Association (ISWA)

The International Solid Waste Association (ISWA) is an independent, non-governmental, non profit making association which objective is the maximum exchange of information and experience world-wide on all aspects of solid waste management (ISWA 1998). It is formed in 1990, and the past 28 years have witnessed widespread and continuous improvement of solid waste management and practices. Its activity is solely in the public interest through professional development of its members; it does not pursue any commercial or political aims. ISWA mission is:

- Promote and Develop Professional Solid Waste Management World-Wide
- Protect human health, natural resources and environment
- Provide information
- Promote research and development, education and training
- Influence policies by providing advice
- Serve the membership

These guidelines are not too technical but suggest a framework for waste management best practice. It is applicable to both developed and developing countries and regional organisations. In order this, all countries should establish a national environmental policy reflecting and referring to widely accept international agreements and guidelines with regard to waste management. Such policy should respect the principles of sustainable development as explained in Brundtland report and the principles set out in Agenda 21. These should include an Action Plan to establish environmentally and economically sound waste management practices.

In terms of it organisation, ISWA is governed by a General Assembly consisting of National representatives and is managed by an Executive and Strategic Planning Committee with a number of Standing Committees. It has National members in 20 countries and organisation and individual members in 80 countries where the key role is to contribute to the definition and identification solid waste management policies and practices that are consistent with sustainable development and creating awareness and encouraging implementation of these practices throughout the world. The association has two periodicals. The Waste Management & Research, a by-monthly journal which is a well known international scientific journal in the field of solid waste management and the ISWA Times the association newsletter which published four times per year, with providing information about the state-of-the-art, articles on selected topics and announcement of conferences and training courses between other general information. The ISWA Yearbook is the International Directory of Solid Waste Management, must be the most complete annual reference work on the subject of solid waste, containing the state of the art information from the ISWA working groups, general articles, and all the association members information.

Construction and Demolition Research, Development and Training

All the international organisations referred in this work has significant concerns in these research, development and training areas, specially when dealing with sub development countries and the most poor countries where sustainability will be building with concerns just even in the foundations. In which concerns to the UN, following a

1963 decision of the General Assembly, the United Nations Institute for Training and Research (UNITAR) was established in 1965, as an autonomous body within the framework of the UN. Its mandate is to enhance through training and research the effectiveness of the UN in achieving major objectives not only on the maintenance of peace and security bur also on the promotion of economic and social development. The Institute has its headquarters in Geneva (Switzerland), and however has two main functions, research and training it is recently more focused on training (UN 1995:183).

The UNITAR programmes comprise courses on multidisciplinary areas, including environmental management and energy, disciplines where this construction and demolition waste stream is more and more analysed. In which concerns the United Nations University (UNU) it was established in 1973, and it is located in Tokyo (Japan). UNU is an autonomous Institution within the framework of the UN and it is a new kind of academic Institution that works to promote scholarly international and scientific co-operation to help solve urgent global problems. It has no students of its own, no faculty and no campus. It operates through worldwide networks of academic and research Institutions, including its own research and training centres and programmes, as well as individual scholars, to address global problems. The UNU has the following Research Training Centres and Programmes with other Institutions:

- UNU, World Institute for Development Economics Research (UNU/WIDER), Helsinki, Finland.

- UNU, Institute for New Technologies (UNU/TECH), Maastrich, The Netherlands.

- UNU, International Institute for Software Technology (UNU/IIST), Macau, Portugal.

- UNU, Institute for Natural Resources in Africa (UNU/INRA), Accra, Ghana, with a Mineral Resources Unit in Lusaka, Zambia.

The University has also the Programme for Biotechnology in Latin America and Caribbean (UNU/BIOLAC), Caracas, Venezuela.

Also the Organisation for Economic Co-operation and Development (OECD), and the European Union by the EEA and the ETCWEU with headquarters in Copenhagen (Denmark), the Institute for Prospective Technological Studies, A EU Joint Research Centre located at Seville, (Spain), which produced between other studies referred in Chapter 2, about the legal definition of waste and its influence on waste management in Europe (EC/IPTS 1997), as well some international consultants has been developed research in this area. Other countries, by their Public Authorities, Universities, Research Institutes and Sector and technical organisations has been also developing research R&D in this priority waste stream, as it has been described in this research.

At EU level the European Parliament and Council Decision concerning the Fifth Framework Programme of the European Community for research, technological development and demonstration activities (1998-2002) (EC 1998) emphasise thematic and horizontal programmes, promoting research, and development and demonstration activities towards a more sustainable society and environment. Before this important EU fifth framework decision, an important document that gives a significant support to the decision was the opinion of the Committee of the Regions of 18 September 1997 to the European Parliament and Council Decision (EC 1997) which welcome the Commission proposal and support their approaches.

The state of the science and technologies was done in Portugal some years ago to prepare research and development (Gago 1992), which has been prepared and asked for proposal every year in specific areas, with grants and funds from EU. The Scientific and Technological Co-operation Institute (ICCTI) and Scientific and Technological Foundation from the Ministry of Science and Technology as the role to promote, present and ask to research proposal in specific areas of knowledge, which priorities has been considered. The Professional, Training and Employment Institute (IEFP) from the Ministry of Employment and Welfare, in partnership with other Ministries promoting training courses in priorities areas. Environmental research projects and progress reports are present annually to the General Directorate of the Environment to evaluate their development in order to achieve global goals and to introduce eventual feedback in projects development (DGA 1997)

In the same sense the CORDIS forms Bulletin and CORDIS database has been disseminating general information about this new R&D programme about the actual Framework 5 (CORDIS 1998).

International organisations which is important to highlight, the International Union of Testing and Research Laboratories for Materials and Structures (RILEM), as well as the International Council for Building Research Studies and Documentation (CIB), has promoting these three fundamental areas in their Conferences, Seminars and Workshop, Technical committees, working and task groups over the world. One world must be done to the work developed in this particular area all over the world by the International Solid Waste Association (ISWA).

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